DEPARTMENT OF THE ARMY TECHNICAL MANUAL

DEPARTMENT OF THE AIR FORCE TECHNICAL ORDER

TM 11-689

TO 31R2-2TRC-151

RADIO SET AN/TRC-29 AND RADIO REPEATER SET AN/TRC-39

DEPARTMENTS OF THE ARMY AND THE AIR FORCE

APRIL 1956

WARNING

EXTREMELY DANGEROUS VOLTAGES EXIST IN THE FOLLOWING UNITS:

Order Wire Transmitter T–389/TRC–29	300 volts
Radio Transmitter T–303/G	2,000 volts
Power Supply PP–764/G	2,000 volts
Power Amplifier T–303/G	1,000 volts
Modulator T–303/G	2,000 volts
Order Wire Receiver R–543/TRC–29	300 volts
Radio Receiver R–418/G	1,000 volts
Power Supply PP–689/G	1,000 volts
Power Supply PP–690/G	1,000 volts
Radio Transmitter T–303/G	2,000 volts

TECHNICAL MANUAL
No. 11–689
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THE AIR FORCE

WASHINGTON 25, D. C., *5 April 1956*

RADIO SET AN/TRC–29 AND RADIO REPEATER SET AN/TRC–39

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CHAPTER 1

INTRODUCTION

Section I. GENERAL

1. Scope

a. Equipment Information. This manual contains information on the theory, installation, operation, maintenance, and repair of Radio Set AN/TRC–29 (fig. 1).

b. Specific System Information. Specific system information is furnished for a pulse-position modulation radio relay system nomenclatured as Radio Repeater Set AN/TRC–39. This set includes two Radio Sets AN/TRC–29.

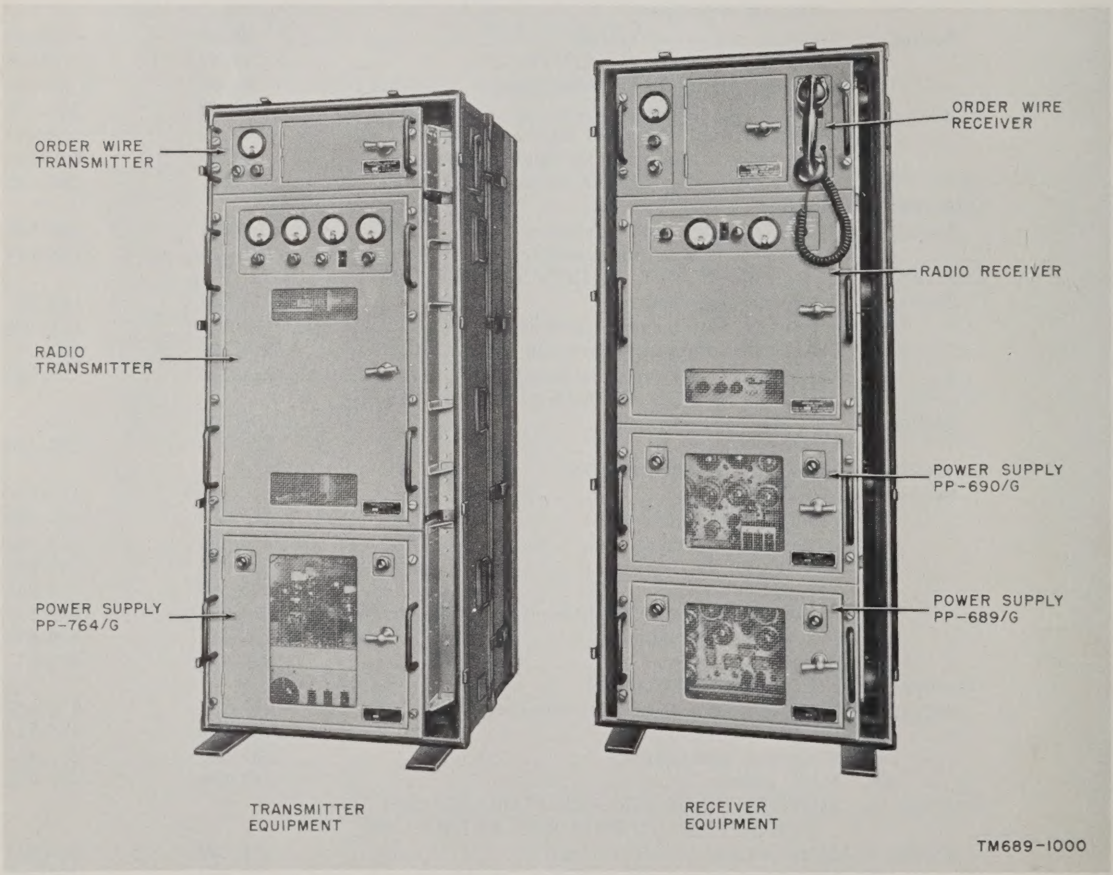

ORDER WIRE TRANSMITTER
RADIO TRANSMITTER
POWER SUPPLY PP-764/G
TRANSMITTER EQUIPMENT
ORDER WIRE RECEIVER
RADIO RECEIVER
POWER SUPPLY PP-690/G
POWER SUPPLY PP-689/G
RECEIVER EQUIPMENT
TM689-1000

Figure 1. Radio Set AN/TRC–29.

c. General System Information. Radio Set AN/TRC–29 normally is used in a rear-area radio relay system.

d. Comments. Forward comments on this publication to the Commanding Officer, The Signal Corps Publications Agency, Fort Monmouth, N. J.

2. Forms and Records

a. Unsatisfactory Equipment Reports.

(1) DA Form 468 (Unsatisfactory Equipment Report) will be filled out and forwarded to the Office of the Chief Signal Officer as prescribed in AR 700–38.

(2) DD Form 535 (Unsatisfactory Report) will be filled out and forwarded to Commanding General, Air Materiel Command, Wright-Patterson Air Force Base, Dayton, Ohio, as prescribed in AR 700–38 and AF TO OO–35D–54.

b. Damaged or Improper Shipment Report. DD Form 6 (Report of Damaged or Improper Shipment) will be filled out and forwarded as prescribed in AR 700–58.

c. Preventive Maintenance Forms.

(1) DA Form 11–238 (Operator First Echelon Maintenance Checklist for Signal Corps Equipment (Radio Communication, Direction Finding, Carrier, Radar)) will be prepared in accordance with instructions on the back of the form (fig. 115).

(2) DA Form 11–239 (Second and Third Echelon Maintenance Checklist for Signal Corps Equipment (Radio Communication, Direction Finding, Carrier, Radar)) will be prepared in accordance with instructions on the back of the form (fig. 116).

Section II. APPLICATION

3. Purpose and Use

a. Equipment Information. Radio Set AN/TRC–29 is a 23-channel, radio relay equipment that is built to satisfy field service handling requirements although it is used normally in a rear-area radio relay system. The equipment can be transported by military trucks without the need of protection or packaging beyond that furnished by the basic equipment transit cases. The equipment operates satisfactorily where temperatures range from —40° F. to +132° F., relative humidity to 95 percent, when sheltered from direct or windblown rainfall.

b. Equipment Packaging. All the equipment is packaged in Electrical Standardized Components Case CY–1280/U to reduce to a minimum the amount of cabling necessary to install a station. The cases are 2 feet by 2 feet by 5 feet high and contain shock-mounted racks. The equipment is ready for operation upon the removal of the interchangeable front and rear transit case covers and the addition of a few interconnecting cables. The individual transit cases, when closed for field transportation, weigh close to 500 pounds. When desired, the equipment can be removed from the field transit case and mounted in standard 19-inch frame racks or standard cabinet racks, which support the equipment either from the front panel or through the equipment center line.

c. Equipment Operation. The equipment is designed for continuous 24-hour service over long periods of time. Once the tube-aging patterns are determined, weekly preventive maintenance checks are required to keep the equipment in operation without failure. While the failure patterns are being established, the equipment stations will be manned by operating personnel. Necessary sensing circuits are included in the radio equipment to enable operation with Control Monitor Group AN/TRA–11, which may be added to an operating station at a later date without modification of the radio sets. The addition of the monitor group permits automatic switchover to a stand by radio set when an operating set becomes defective.

4. System Application

a. General System Information. Radio Set AN/TRC–29 is frequency-modulated (fm) radio relay equipment that provides communication trunk service over as many as 20 tandem hops and forms circuits up to 600 miles in length. Various modulator equipments may be used over the modulation bandwidth of 30 cycles per second (cps) to 4.5 megacycles (mc). The radio equipment operates in the 1,700- to 2,400-mc microwave frequency spectrum where acceptable propagation paths must have adequate clearance above all intervening obstacles, such as hills, trees, and buildings. The high circuit quality needed for multichannel voice toll circuits limits the length of a hop between repeater stations to 30 miles line-of-sight for all multiple hop circuits. Point-to-point services that do not require toll quality and can be out of communication because of radio noise from 2 to 5 percent of the time may be operated over much greater hop lengths.

b. Antenna Installation. Tower AB–216/U is a semipermanent, sectionalized, guyed, walkup tower that has a cross-sectional area 4 by 6 feet. This tower can be installed in heights from 78 to 204 feet. A trained 4-man crew can install the 78-foot tower in 1 hour after the anchors are dug in. The towers require one cargo truck for each 78 feet of tower. The towers weigh 3,820, 4,866, 6,141, and 7,717 pounds for 78-, 120-, 162-, and 204-foot sizes, respectively. The tower sections are painted white and require only orange banding to conform to zone of interior and rear-area aircraft visibility requirements. For tactical applications, the towers may be painted olive drab.

c. System Maintenance. To maintain long radio relay circuits, an order-wire circuit with ringing facilities connects all radio units on a party-line basis. This order-wire circuit is independent of any communication over the 23-voice channels and cannot be used for through traffic. The order wire operates through Radio Set AN/TRC–29 on a 6-mc subcarrier with integral order-wire transmitters and receivers.

d. Specific System Information. Although Radio Set AN/TRC–29 is capable of transmitting television, radar data, frequency-division, and time-division signals, specific system information is furnished for a pulse-position modulation (ppm) radio relay system only. Nomenclature has not been assigned all the equipment combinations used as a series of the AN/TRC equipments; only the four station combinations most commonly used have been nomenclatured. The individual equipment is nomenclatured so that other systems can be made up by proper equipment requisition. Radio-Telephone Terminal Set AN/TRC–38, Radio Repeater Sets AN/TRC–39, AN/TRC–40, and AN/TRC–41 handle ppm signals and each group includes two or more Radio Sets AN/TRC–29.

5. Terminal and Repeater Equipment

a. Video Equipment. Radio Set AN/TRC–29 requires an external source of video modulating signals and does not in itself provide complete communication facilities. Television camera equipment, radar equipment, and voice multiplex equipment generally can be adapted to Radio Set AN/TRC–29.

b. Ppm Terminals. One Multiplexer Set AN/TCC–13 provides 23-voice channels, or two combined multiplexers will provide 45 channels. All alternating current (ac) signals in the 300- to 3,500-cycle voice band, such as supplied by field Telephone EE–8, Facsimile Equipment RC–120, Telegraph Terminal AN/TCC–4, and Telegraph Terminal AN/TCC–20, may be transmitted. Direct current (dc) signals of the trunk supervisory type cannot be transmitted over the voice channels except for remote very high frequency (vhf) radio push-to-talk operation over two channels. Twenty cps ring-through operation between EE–8–type telephones is provided. A 5-inch high-definition Oscilloscope OS–25/G and an Audio Test Set TS–762/TC that provide a 1,000-cps test tone, a level meter, a total distortion meter for 1,000-cps operation, and a signal-to-noise meter for measuring channel noise or crosstalk are provided to enable necessary maintenance and alinement to be made without auxiliary test equipment, except for a vacuum tube voltmeter (vtvm), such as Electronic Millimeter TS–505/U, and a tube checker.

c. Repeater Stations. Repeater stations are intermediate radio stations that are used to extend the range of a radio link. Usually, radio repeater stations have Radio Sets AN/TRC–29 connected back to back to form a video signal patched repeater, and are without auxiliary video equipment. For television systems, an auxiliary dc reinsertion amplifier is required at some repeater stations. For long ppm systems, every fifth or sixth repeater station should reshape the pulse train and restore the ppm pulses to their original shape. Pulse Form Restorer Group AN/TRA–10 and Multiplexer Group AN/TCA–1 will provide ppm reshaping where required.

d. Voice-Channel Drop Repeater Stations. To increase the flexibility of ppm radio link facilities, Multiplexer Group AN/TCA–1 provides facilities for dropping the first 8 of the 23 through-voice channels for local or branch circuit traffic. When no more than two branch circuits are required, Pulse Form Restorer Group AN/TRA–10 may be used to provide drop facilities. When these equipments are used to provide drop facilities at least every six hops, no additional reshaping facilities need be supplied.

e. Equipment Issue. Radio Set AN/TRC–29, Radio-Telephone Terminal Set AN/TRC–38, Radio Repeater Sets AN/TRC–39, AN/TRC–40, and AN/TRC–41 do not include enough transmitter klystron tubes, frequency control crystals, and duplexers to permit operation on any combination of frequencies in the 1,700- to 2,400-mc band. Requisitions must include the desired operation frequencies for both transmitting and receiving, as well as the required towers (no antenna support supplied with the radio sets), shelters, and test equipment.

6. Basic Radio Relay Systems

a. Basic Single-Hop Radio Relay System. A basic radio relay system consisting of two terminals less than 30 miles apart on a line-of-sight basis and joined by one radio link is shown in figure 2. The west terminal signals from the video equipment are fed to the radio transmitter portion of Radio Set AN/TRC–29 to frequency-modulate the microwave carrier output of the transmitter. The modulated microwave carrier is transmitted by an antenna to the east terminal. The antenna at the east terminal picks up the carrier and feeds it to the radio receiver portion of Radio Set AN/TRC–29. The receiver amplifies and detects the signals. The output of the receiver is fed to the video equipment, which demodulates or displays the detected video signals. The duplexer permits the use of a single transmission line and antenna system for both transmitting and receiving.

b. Basic Multiple-Hop Radio Relay System. If two terminals are more than 30 miles apart, additional hops are required to extend the range of the radio link that joins the terminals. Additional hops are accomplished through the use of repeater stations. Figure 3 shows a basic two-hop radio relay system that has one repeater station. The fm microwave carrier output of the radio transmitter at the west terminal is received by the antenna at the repeater station and is fed to the radio receiver. The video output of the receiver is connected to the input of the west-east radio transmitter in the second Radio Set AN/TRC–29, and is used to frequency-modulate the microwave carrier output of the transmitter. The modulated microwave carrier then is transmitted by the second antenna to the east terminal. The reverse signal path from the east terminal to the west terminal is the same as that described above. Through the use of as many as 19 repeater stations, the radio link can be extended to 20 hops to cover a range up to 600 miles.

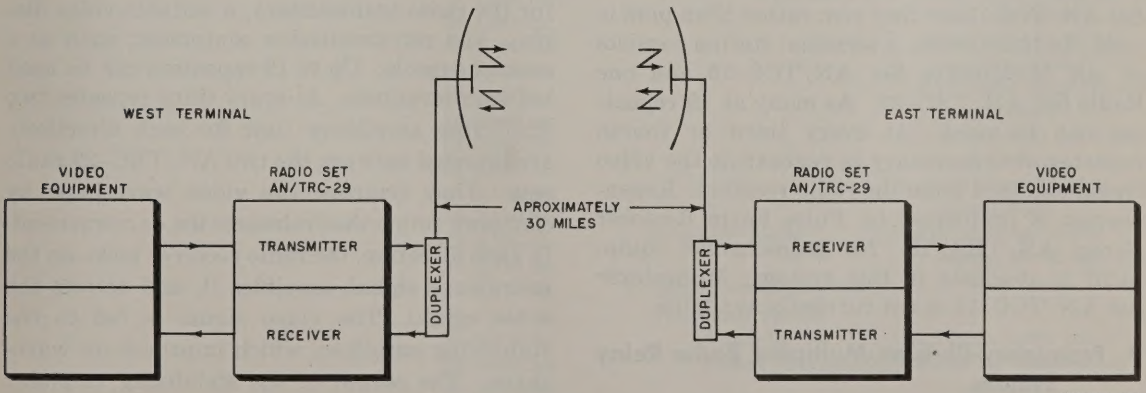


Figure 2. Basic single-hop relay system, block diagram.

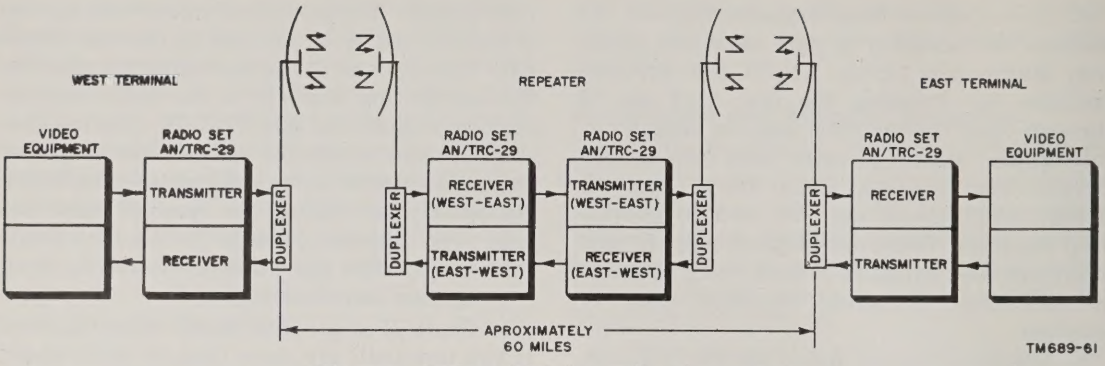

WEST TERMINAL
VIDEO EQUIPMENT
RADIO SET AN/TRC-29
TRANSMITTER
RECEIVER
DUPLEXER
REPEATER
RADIO SET AN/TRC-29
RECEIVER (WEST-EAST)
TRANSMITTER (EAST-WEST)
RADIO SET AN/TRC-29
TRANSMITTER (WEST-EAST)
RECEIVER (EAST-WEST)
DUPLEXER
EAST TERMINAL
RADIO SET AN/TRC-29
RECEIVER
TRANSMITTER
VIDEO EQUIPMENT
APROXIMATELY 60 MILES
TM689-61

Figure 3. Basic multiple-hop radio relay system, block diagram.

7. Types of Radio Relay Systems

Radio Set AN/TRC–29 can be used in the radio link of a versatile radio relay system that can carry such signals as multichannel telephone, facsimile, telegraph, radar, or television. The following examples of radio relay systems using Radio Set AN/TRC–29 will be described:

a. Ppm radio relay system.

b. Pulse-code modulation (pcm) radio relay system.

c. Frequency-division-multiplex radio relay system.

d. Television radio relay system.

e. Switchover.

8. Pcm Radio Relay System

Radio Set AN/TRC–29 can be used with Multiplexer Set AN/TCC–15 and Pulse Form Restorer Group AN/TRA–18 to provide a 48-channel pcm communication system. Multiplexer Set AN/TCC–15 differs from Multiplexer Set AN/TCC–13 in that pcm rather than ppm is used. In this system, a terminal station consists of one Multiplexer Set AN/TCC–15 and one Radio Set AN/TRC–29. As many as 19 repeaters can be used. At every third or fourth repeater, it is necessary to regenerate the video signal obtained from the radio receiver. Regeneration is performed by Pulse Form Restorer Group AN/TRA–18. No drop-channel equipment is available in this system. Multiplexer Set AN/TCC–15 is not currently available.

9. Frequency-Division-Multiplex Radio Relay System

Radio Set AN/TRC–29 can be used with Subcarrier Group AN/TSA–10 and suitable frequency-division-multiplexing equipment to provide a maximum of a 36-channel communication system. Subcarrier Group AN/TSA–10 provides a video subcarrier for a frequency-division-multiplex spectrum of signals. In this system, a terminal consists of one Subcarrier Group AN/TSA–10, one Radio Set AN/TRC–29, and suitable frequency-division-multiplex equipment. Telephone Terminal Carrier Set AN/TCC–7 will provide a 12-channel system. As many as 19 repeaters can be used between terminals. No drop-channel or reshaper equipment is available in this system. Subcarrier Group AN/TSA–10 is not currently available.

10. Television Radio Relay System

Radio Set AN/TRC–29 also can be used with commercial television equipment for transmission of television signals. In this system, the video equipment can consist of a standard camera chain (to supply the video modulating signal for the radio transmitter), a suitable video display, and retransmission equipment, such as a control console. Up to 19 repeaters can be used between terminals. At every third repeater two stabilizing amplifiers (one for each direction) are inserted between the two AN/TRC–29 radio sets. They improve the video waveshape by clamping action that reinserts the dc component. In each direction, the radio receiver picks up the microwave signal, amplifies it, and detects the video signal. The video signal is fed to the stabilizing amplifier, which improves its waveshape. The output of the stabilizing amplifier then is fed to the radio transmitter for transmission to the next repeater.

11. Switchover System

Radio Set AN/TRC–29 provides the circuitry for automatic switchover with Control Monitor Group AN/TRA–11. The control monitor group automatically switches from operating radio equipment to spare radio equipment if the operating equipment fails. It will be used either at terminal stations or at repeater stations employing Radio-Telephone Terminal Set AN/TRC–38, Radio Repeater Set AN/TRC–39, AN/TRC–40, or AN/TRC–41. It will be used whenever it is desirable to have a rapid, reliable changeover at manned stations or when unattended operation is desired. In addition to the basic automatic transfer operation, fault location, fault identification, fault alarm, and fault recording features will be provided.

Section III. DESCRIPTION AND DATA

12. Technical Characteristics of Radio Set AN/TRC–29

a. General. The transmitter of Radio Set AN/TRC–29 includes a SRL–7 series klystron oscillator followed by a 2C39A lighthouse triode amplifier that has a 10-watt output. The klystron is held to the desired carrier frequency (within .03%) by a motor drive, which is controlled by an automatic frequency control (afc) circuit that has a crystal oscillator as a reference. The receiver local oscillator is an external cavity klystron type 6BM6.

b. Transmitting Equipment.

Frequency range:	
Tunable	1,700 to 2,400 mc.
Preset channels (27)	Channel 1–1,715 mc 2–1,745 mc 3–1,775 mc 4–1,805 mc 5–1,835 mc 6–1,860 mc 7–1,885 mc 8–1,910 mc 9–1,935 mc 10–1,960 mc 11–1,980 mc 12–2,000 mc 13–2,020 mc 14–2,040 mc 15–2,065 mc 16–2,090 mc 17–2,115 mc 18–2,140 mc 19–2,165 mc 20–2,190 mc 21–2,215 mc 22–2,245 mc 23–2,275 mc 24–2,310 mc 25–2,335 mc 26–2,360 mc 27–2,385 mc
Frequency:	
Stability	0.03% (crystal reference controlled)
Modulation	Fm, deviation ±3.6 mc (nominal)
Video input requirements:	
Impedance	50 ohms
Frequency	30 cps to 4.5 mc
Level, video	−3 to +7 dbm; 158 millivolts rms (.22-volt peak) to 500 millivolts rms (.7-volt peak)
Power requirements:	
Power Supply PP–764/G:	
Input	115 volts ac
Outputs	−1,000 volts dc at 214 ma (regulated) +820 volts dc at 110 ma (unregulated) −1,350 volts dc at 15 ma (unregulated floating)
Power Supply PP–689/G:	
Input	115 volts ac
Outputs	+300 volts dc at 155 ma (regulated) +250 volts dc at 245 ma (regulated) +150 volts dc at 210 ma (regulated) +42 volts dc at 8 ma (regulated) +150 volts dc at 2 ma (regulated)
Primary power	115 volts ac, 1,675 watts, 50/60 cps

c. Receiver Equipment.

Frequency range:	
Tunable	1,700 to 2,400 mc
Preset channels (27)	Same as transmitter equipment
Type	Single-conversion superheterodyne

Type of modulation received	Fm
Intermediate frequency	120 mc
Frequency control	Automatic frequency control
Gain control	Automatic gain control and manual gain control
Antenna input	50 ohms
Video output	30 cps to 4.5 mc; −3 to +7 dbm; 158 millivolts rms (.22-volt peak) to 500 millivolts rms (.7-volt peak)
Selectivity	70 db down at 37.5 mc from carrier frequency
Noise figure	14 db to 16 db
Power requirements:	
Power Supply PP–690/G:	
Input	115 volts ac
Output	+250 volts dc at 101 ma (regulated) +150 volts dc at 200 ma (regulated) −625 volts dc at 10 ma (unregulated) −475 volts dc at −8 ma (unregulated) +42 volts dc at 8 ma (regulated) −300 volts dc at 13 ma (regulated)
Primary power requirements	115 volts ac, 565 watts, 50/60 cps

d. Primary Power Requirements, Overall.

Primary operating power	115/230 volts ac, 2,300 watts, 550/60 cps
Transmission line de-icing power	115 volts ac, 1,000 watts

e. Antenna Equipment.

Type	Horn-fed parabolic reflector
Size	8-foot diameter paraboloid
Polarization	Vertical or horizontal
Gain	30 db
Antenna beamwidth	4.5° (3-db points)
Major-to-minor lobe ratio	20 db
Antenna feed line	Radio Frequency Transmission Line Assembly CG–1013/U.

f. Fixed Autotransformer Power Transformer TF–146/G.

Input	100 to 130 volts ac, or 200 to 260 volts ac
Output	115 volts ac ±4.0 volts ac, 4 kva maximum

g. Radio Frequency Transmission Line Assembly CG–1013/U.

(1) *Surface-wave transmission line assembly.*

Type	Single wire, guided wave
Frequency range	1,700 to 2,400 mc
Operating loss	5 db to 7.5 db, 50 ft to 250 ft length
Voltage standing wave ratio	1.5 maximum
Transmission	Transverse magnetic, radially symmetric, nonradiating wave
Input and output impedance	50 ohms
Length	50 feet to 250 feet (2 ea 250-foot rolls supplied)
Material	No. 10 AWG copper wire coated with .015 in. polyethylene
Termination	Launching unit at each end with rf Plug Connector UG–707/U when connecting cables are used

(2) *De-icing assembly.*

Operating voltage	115 v, 47.5 to 63 cps
Rating	1 kva
Output voltage	10 v, 14 v, 19 v, or 24 v
Heating current	40 to 60 amperes

13. Technical Characteristics of Single-Hop Radio Relay System

Video bandwidth	30 cps to 4.5 mc
Signal-to-noise ratio	37 db nominal (over 30-mile path 4.5 mc bandwidth).

14. Technical Characteristics of Ppm Radio Relay System (23 to 45 Channels)

Channel frequency bandwidth	300 to 3,400 cps

Channel characteristics:

Signal-to-noise ratio:	Single-hop	Multi-hop
23 channels	55 db	3 db less than single-hop figure for each doubling of number of hops.
45 channels	50 db	

Forward adjacent crosstalk:	Single-hop	Multi-hop
23 channels	50 db	3 db less than single-hop figure for each doubling of number of hops.
45 channels	45 db	
Maximum number of hops	20 rf hops; 10 hops if hybrid-connected, back-to-back terminals are used.	

15. Packaging Data for Radio Set AN/-TRC-29

a. When packed for export shipment, the components of Radio Set AN/TRC-29 are placed in moisture-vaporproof containers and packed in 13 crates. Crate No. 11 contains Electrical Power Cable Assembly CS-2440/U (150 ft) wound on Reel RC-405/TR. Crates No. 12 and 13 contain the transit cases that house the components of Radio Frequency Transmission Line Assembly CG-1013/U. Antenna AS-554/TRC-29 is packed in five transit cases that are inclosed in crates No. 5 through 9. The other crates contain the transit cases that house the various component, accessories, and spares of Radio Set AN/TRC-29. The number, size, weight, and contents of each crate are indicated in the chart below. This chart does *not* include the crates that contain the transit cases of Tower AB-216/U. Refer to TM 11-5073, Tower AB-216/U, Tower Section Set AB-298/U, Guy Kit MK-99/U, Accessory Kit MK-100/U, Guy Kit MK-101/U for this information.

Packed for Shipment

Crate No.	Contents	Height (in.)	Width (in.)	Depth (in.)	Volume (cu ft)	Unit weight (lb)
1	Electrical Standardized Components Case CY-1280/U, transmitter rack.	62	29	29	30.18	620
2	Electrical Standardized Components Case CY-1280/U, receiver rack.	62	29	29	30.18	620
3	Chest CY-250/U, spare parts case I	29½	23½	22½	7	204
and						
4	Chest CY-250/U, spare parts case II	29½	23½	22½	7	204
5,	Antenna AS-554/TRC-29	70	21	20	17	260
6,		66	17½	16¾	9.5	235
7,		65½	48	25½	46.9	313
8,		65½	48½	25½	46.9	313
and						
9		92½	9¼	4¾	2.36	68
10	Fixed Autotransformer Power Transformer TF-146/G.	31½	17½	16½	5.26	305
11	Electrical Power Cable Assembly CX-2440/U (150 ft) on Reel RC-405/TR.	31	31	15	8.35	150
12	Radio Frequency Transmitter Line Assembly CG-1013/U.	39½	20	17½	8	195
and						
13		39½	20	17½	8	195
Total weight (lb)						3,682

Notes:

1. Items may be packed in a manner different from that shown, depending upon the supply channel.
2. Crate numbers are used for reference only.

b. When packaged for export shipment, the surface-wave transmission line is packed in two wooden crates. One crate weighs 100 pounds and contains the de-icing transformer assembly. The other crate weighs 90 pounds and contains the carrying case and all the remaining components of the surface-wave transmission line. See figure 4 for a picture of the carrying cases.

(1) The de-icing transformer assembly is cushioned with cells and pads of corrugated fiberboard. The cushioned deicing transformer assembly together with a desiccant is packed in a corrugated fiberboard box. The fiberboard box is placed in a water-vaporproof barrier, then in another fiberboard box. The packaged de-icing transformer assembly then is placed in a wire bound wooden crate.

(2) The carrying case that contains the remaining components is packed in a fiberboard box and cushioned with flexible corrugated paper. The packaged carrying case then is placed in a wire bound wooden crate.

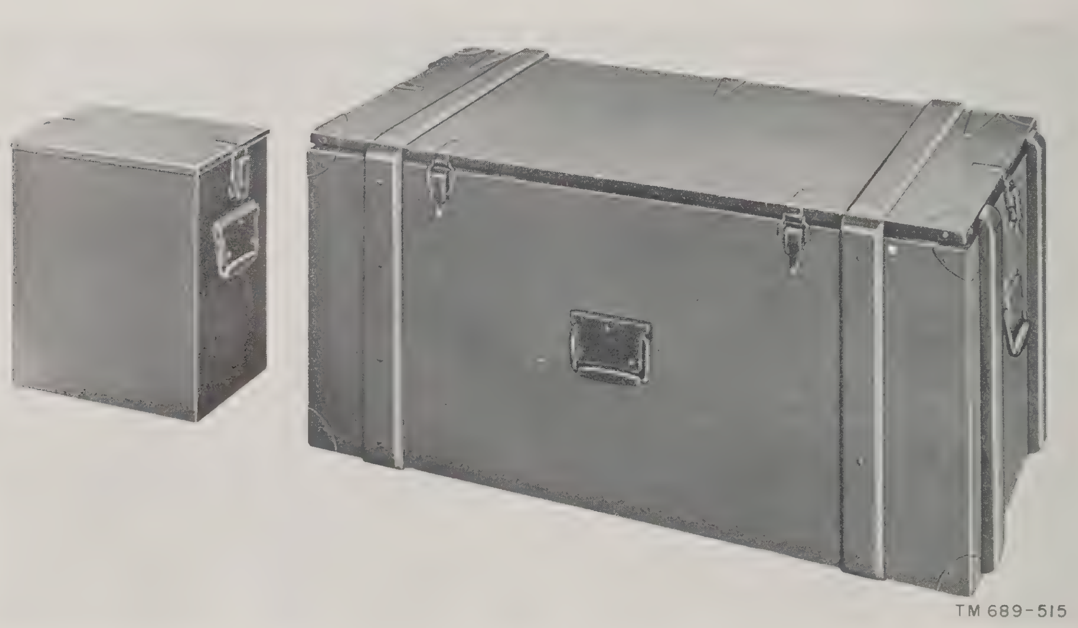


Figure 4. Radio Frequency Transmission Line Assembly CG-1013/U, carrying cases.

c. The following chart indicates the contents of each case. See the packing list attached to each case for exact contents.

Case Contents

Case	Contents	Notes
Cable and reel assembly	Electrical Power Cable Assembly, CX-2440/U (150 ft) and Reel RC-405/TR.	Refer to paragraph 32.
Antenna AS-554/TRC-29:		Refer to figures 15 and 16.
Antenna case I	Antenna feed horns (2 ea)	
Antenna case II	Antenna castings.	
Antenna case III	Two reflector quarter sections and half yoke.	
Antenna case IV	Two reflector quarter sections and half yoke.	
Antenna case V	Antenna pipe sections.	

Case Contents—(Continued)

Case	Contents	Notes
Electrical Standardized Components Case CY–1280/U:		
Receiver Rack	Receiving equipment and power supply (including low-voltage power supply).	Refer to paragraph 24.
Transmitter Rack	Transmitting equipment and high-voltage power supply (less low-voltage power supply).	Refer to paragraph 19.
Chest CY–250/U:		
Spare parts case I	Running spare parts	Refer to paragraph 34.
Spare parts case II	Cable assemblies, Switch Box SA–357/G, and Handset-Signaling Unit H–102/TRC–29.	Refer to paragraphs 31 and 32. Cord CG–409/U (2 ft 6 in.) is in the transmitter rack and CG–409/U (1 ft and 7 in.) is in the receiver rack.
Fixed Autotransformer Power Transformer TF–146/G.	Autotransformer	Refer to paragraph 31.

16. Common Name Versus Nomenclature

A list of the common names for the components of the radio set is given below.

Nomenclature	*Common Name*
Antenna AS–554/TRC–29	Antenna.
Antenna case I	Dipole case.
Antenna case II	Casting case.
Antenna case III	Carrying frame case.
Antenna case IV	Carrying frame case.
Antenna case V	Antenna bag.
Radio Frequency Transmission Line Assembly CG–1013/U	Surface-wave transmission line.
Electrical Standardized Components Case CY–1280/U:	Transit case.
With receiving equipment	Receiver rack.
With transmitting equipment	Transmitter rack.
Chest CY–250/U (2)	Spare parts case I. Spare parts case II.
Duplexer CU–368/TRC–29	Duplexer.
Duplexer CU–369/TRC–29	Duplexer.
Handset-Signaling Unit H–102/TRC–29	Remote handset.
Power Supply PP–690/G	Receiver power supply.
Power Supply PP–689/G	Low-voltage power supply.
Power Supply PP–764/G	High-voltage power supply.
Order Wire Receiver R–543/TRC–29	Order-wire receiver.
Radio Receiver R–418/G	Radio receiver.
Switchbox SA–357/G	Switchbox.
Reel RC–405/TR	Reel.
Fixed Autotransformer Power Transformer TF–146/G	Autotransformer.
Tower AB–216/U	Tower.
Order Wire Transmitter T–389/TRC–29	Order-wire transmitter.
Radio Transmitter T–303/G	Radio transmitter.

17. Table of Components

a. Radio Set AN/TRC–29.

Uncrated Weights and Dimensions

Component	No. reqd	Length (in.)	Width (in.)	Height (in.)	Volume (cu ft)	Weight (lb)
Electrical Standardized Components Case CY–1280/U, containing:	1	26½	26½	59½	24.9	517
Order-Wire Transmitter T–389/TRC–29	1	21⅝	19⅜	7	1.7	
Radio Transmitter T–303/G	1	21	19⅜	29¾	7.1	
Power Supply PP–764/G	1	21	19⅜	17½	4.2	

Uncrated Weights and Dimensions—(Continued)

Component	No. Reqd	Length (in.)	Width (in.)	Height (in.)	Volume (cu ft)	Weight (lb)
Electrical Standardized Components Case CY–1280/U, containing:	1	26½	26½	59½	24.9	534
Order-Wire Receiving R–543/TRC–29	1	22⅜	19⅜	10½	2.7	
Radio Receiver R–418/G	1	21⅝	19⅜	19¼	4.9	
Power Supply PP–690/G	1	21⅝	19⅜	12¼	3.1	
Power Supply PP–689/G	1	21	19⅜	21¼	5.1	
Chest CY–250/U, containing running spares (par. 34*a*)	1	27	21¼	20	6.56	111
Chest CY–250/U, containing accessories and small parts (par. 34*b*).	1	27	21¼	20	6.56	124
Antenna case I	1	66	17½	16¾	13.6	160
Antenna case II	1	47¾	12½	14	6.4	184
Antenna case III	1	23⅝	81½	54¼	60.6	178
Antenna case IV	1	23⅝	81½	54¼	60.6	178
Antenna case V	1	125	24		1.5	33
Power Transformer Fixed Autotransformer TF–146/G	1	19	15	13⅞	2.3	170
Reel RC–405/TR with Electrical Power Cable Assembly CX–2440/U (150 ft).	1	28 dia	----------	12	4.27	108
Radio Frequency Transmission Line Assembly CG–1013/U, case I.	1	36½	19	18	----------	22
Radio Frequency Transmission Line Assembly CG–1013/U, case II.	1	36½	19	18	----------	22
Special procurement components*						

* See paragraph 33.

Note. This list is for general information only. See SIG 7 & 8 AN/TRC–29 for information pertaining to the requisition of spare parts. Refer to paragraph 36 for a list of additional equipment required but not supplied.

b. Radio Frequency Transmission Line Assembly CG–1013/U (fig. 17).

Component	Reqd No.	Height (in.)	Depth (in.)	Length (in.)	Unit weight (lb)
Transmission line	2	----------	----------	250 ft	16.5
Launching unit	2	8 5/16	8 5/16	33	3.5
De-icing transformer assembly	1	14¼	8	15⅛	97
Guy assembly	1	----------	----------	----------	3
Anchor screw	1	----------	----------	30 ft	4
Guy stake GP–112/G	1	----------	----------	18¾	3
Clevis	2	----------	----------	----------	----------
Eyebolt	1	----------	----------	12	.75
Rf cable assembly (radio feed)	1	----------	----------	15 ft	2
Rf cable assembly (antenna feed)	1	----------	----------	10 ft	1.5
Power cable assembly (ac power)	1	----------	----------	30 ft	3
Power cable assembly (de-icing assembly to tower).	1	----------	----------	25 ft	2.75
Power cable assembly (de-icing assembly to launching unit).	1	----------	----------	10 ft	1.5
Power cable assembly (tower to launching unit)	1	----------	----------	5 ft	.25
Carrying case	1	18	19	36½	22

18. Arrangement of Components of Radio Set AN/TRC–29

a. The major components of Radio Set AN/TRC–29, with the exception of Antenna AS–554/TRC–29, are mounted in two Electrical Standardized Components Cases CY–1280/U (fig. 5). The two transit cases are identical except for the placement of the alining pins that are mounted on each frame for guiding the components into place. One transit case, with transmitting components, is referred to as the *transmitter rack* and the other transit case, with receiving components, is referred to as the *receiver rack.*

b. The antenna is arranged for mounting on Tower AB–216/U, which is not supplied as part of Radio Set AN/TRC–29. See paragraph 29.

19. Description of Transmitter Rack, General

The transmitter rack (fig. 7) consists of the transit case and the components listed in *a* through *c* below. A description of the case is contained in paragraph 20 and descriptions of the components are contained in paragraphs 21 through 23.

a. Order-Wire Transmitter T–389/TRC–29.

b. Radio Transmitter T–303/G.

c. Power Supply PP–764/G.

20. Description of Electrical Standardized Components Case CY–1280/U

(figs. 5 and 6)

a. Electrical Standardized Components Case CY–1280/U consists of an equipment mounting rack and two covers, front and rear. The two covers are identical, interchangeable, and can be moved completely from the equipment mounting rack. Three carrying handles and a J-hook, used when lifting the transit case with a crane, are bolted to each side of the equipment mounting rack. An air escape vent is located in each side of the rack. When the equipment is transported by air, the vent insures equal air pressure, inside and outside the transit case.

b. The equipment mounting rack consists of an outer framework to which a welded metal inner frame is shock-mounted by eight shockmounts. This shock-mounted frame can hold a maximum load of approximately 300 pounds. The components are mounted on the inner frame by screws. The inner frame is drilled and tapped for standard 19-inch relay rack spacing. Removable alining pins, mounted on the frame, guide the components into place. Two metal feet are bolted to the bottom of the outer frame. These project front and rear to provide better balance for the rack when the covers are removed and the equipment is installed, and also to allow the equipment to be bolted to the floor.

21. Description of Order-Wire Transmitter T–389/TRC–29

a. The order-wire transmitter (figs. 7–10) is located at the top of the transmitter rack. A removable gray metal cover frame is mounted to the front of the chassis by four thumbscrews. The frame has a cutout on the left through which appear the order-wire transmitter meter, meter selector switch knob, and the TRANSFER CONTROL ON indicator lamp. The frame has a door through which the main panel and unit controls can be seen and reached. Mounted on a separate bracket immediately behind the door are the PLATE and FIL circuit breakers. The main components of the order-wire transmitter are mounted on a recessed panel behind the circuit breakers. On this panel are the ORDER WIRE TEST SWITCH and the TRANSFER CONTROL-MANUAL OPERATE switch. Other screwdriver controls are also mounted on the recessed panel. The functions of all controls are described in paragraphs 72 through 82.

b. The rear of the order-wire transmitter is covered by a perforated metal cover that is secured to the chassis by four Dzus fasteners. When removed, the rear cover operates an interlock switch. Protective covers are mounted by screws to the top and sides of the chassis. Handles are mounted on the front and rear of the chassis. Connections with other units in the transmitter rack are made through a wire harness that passes through an opening in the rear cover and connects to a terminal board in the rear of the chassis. Other connections to the chassis are made through receptacles that are reached from the rear.

c. TRANSFER CONTROL, ORDER WIRE INTERCONN, and ORDER WIRE CARRIER OUTPUT receptacles are located on the rear panel.

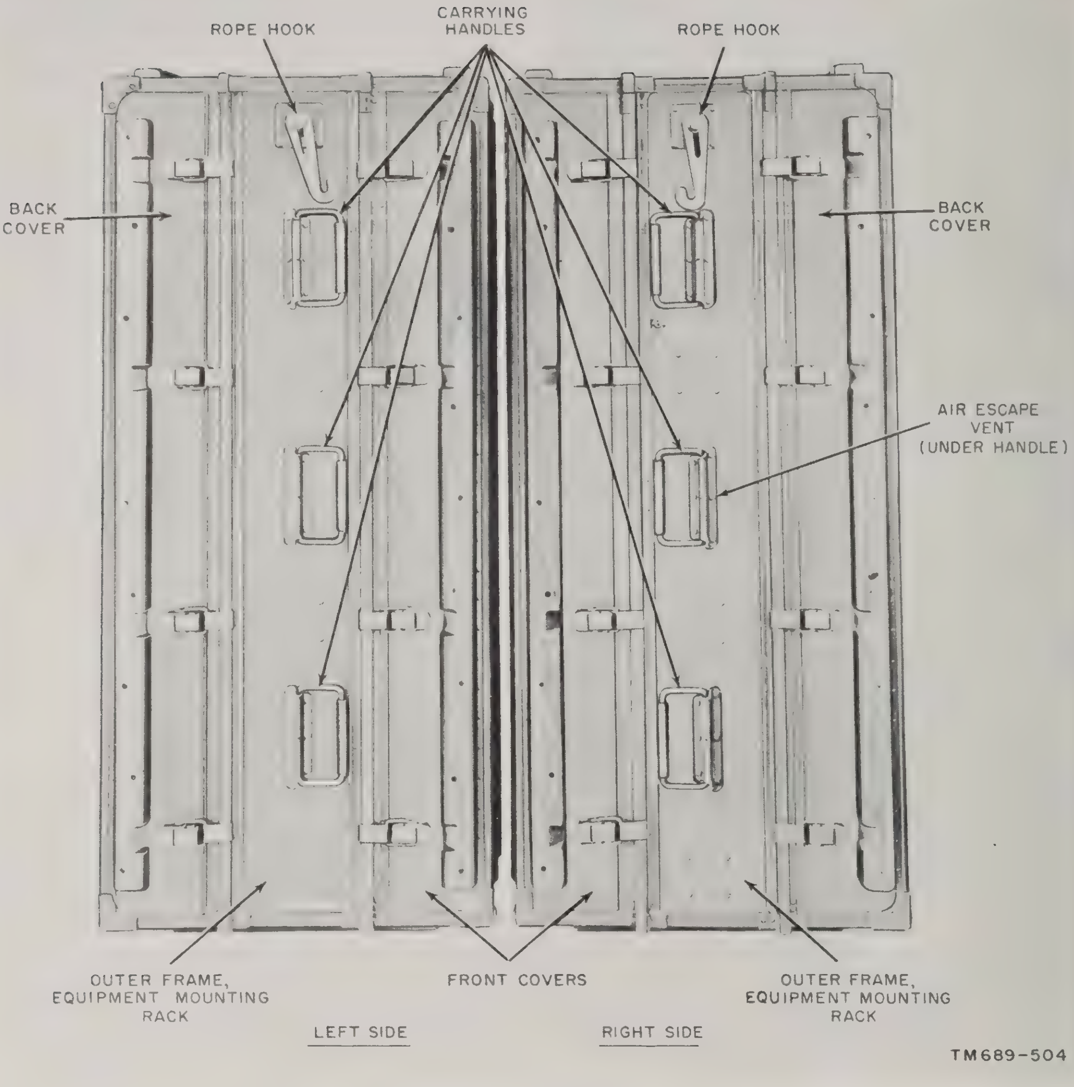

CARRYING HANDLES
ROPE HOOK
ROPE HOOK
BACK COVER
BACK COVER
AIR ESCAPE VENT (UNDER HANDLE)
OUTER FRAME, EQUIPMENT MOUNTING RACK
FRONT COVERS
OUTER FRAME, EQUIPMENT MOUNTING RACK
LEFT SIDE
RIGHT SIDE
TM689-504

Figure 5. Electrical Standardized Components Case CY–1280/U, side view.

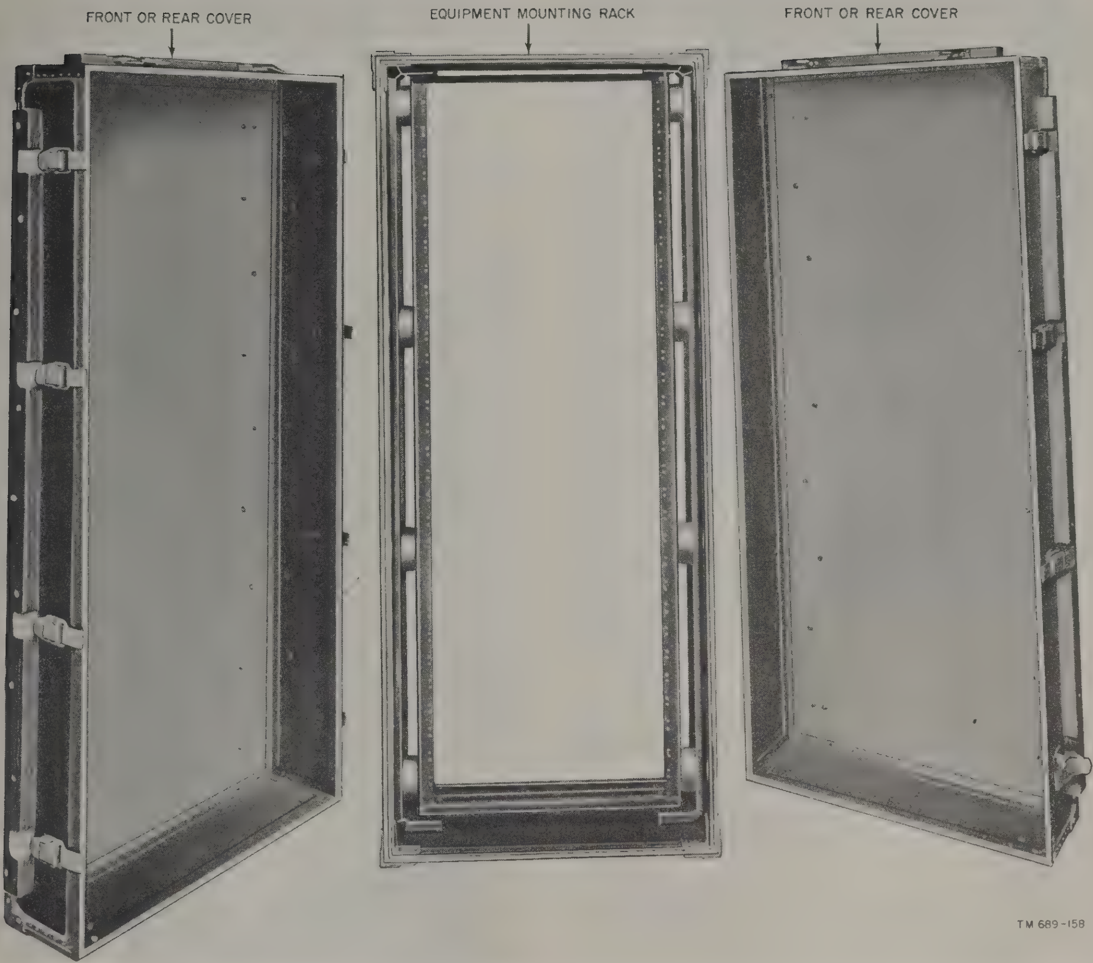

FRONT OR REAR COVER
EQUIPMENT MOUNTING RACK
FRONT OR REAR COVER
TM 689-158

Figure 6. Electrical Standardized Components Case CY–1280/U, covers removed.

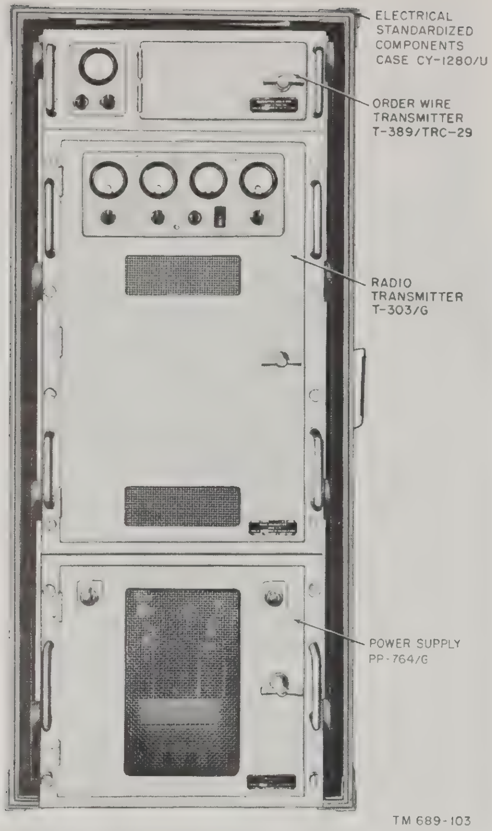

ELECTRICAL STANDARDIZED COMPONENTS CASE CY-1280/U
ORDER WIRE TRANSMITTER T-389/TRC-29
RADIO TRANSMITTER T-303/G
POWER SUPPLY PP-764/G
TM 689-103

Figure 7. Transmitter rack, front view.

22. Description of Radio Transmitter T–303/G

a. General. Radio Transmitter T–303/G is the center chassis in the transmitter rack (figs. 7 and 10).

(1) The main panel of the radio transmitter is covered by a removable gray metal cover frame with an access door. The frame is secured to the front of the chassis by eight thumbscrews. The access door has a large cutout at the top through which the transmitter meter panel is visible. The door has two smaller wire-screened cutouts for chassis ventilation. A frequency calibration chart, two hexagonal wrenches, and an insulated tuning tool are mounted to the inside of the access door.

(2) The rear of the transmitter is protected by a metal cover. A 30-foot length of Radio Frequency Cable RG–21A/U is mounted and clamped directly to the rear cover and serves as a 20-decibel (db) attenuator. The rear cover, when removed, operates an interlock switch that cuts off B+ power to the transmitting equipment. The switch can be set for operation of the transmitter with the cover removed, by pulling the interlock switch rod out beyond its off position. Protective

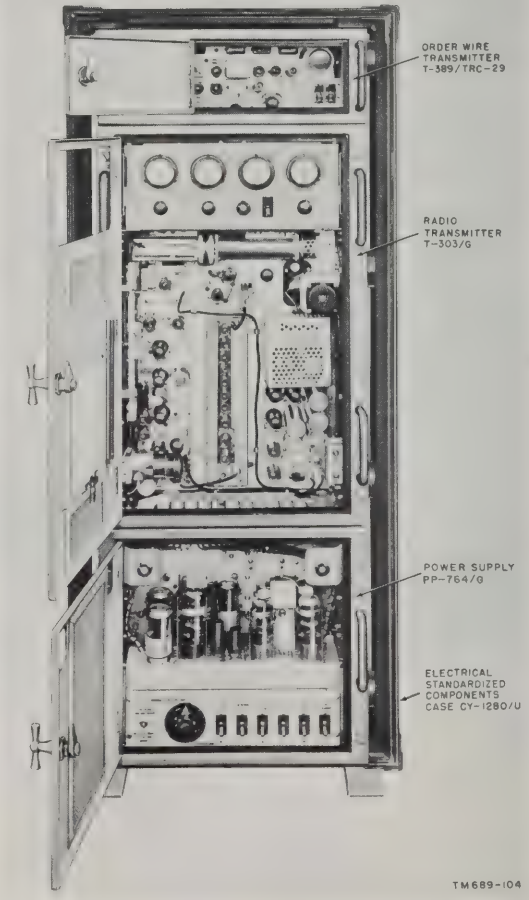

ORDER WIRE TRANSMITTER T-389/TRC-29
RADIO TRANSMITTER T-303/G
POWER SUPPLY PP-764/G
ELECTRICAL STANDARDIZED COMPONENTS CASE CY-1280/U
TM689-104

Figure 8. Transmitter rack, front view with components access doors open.

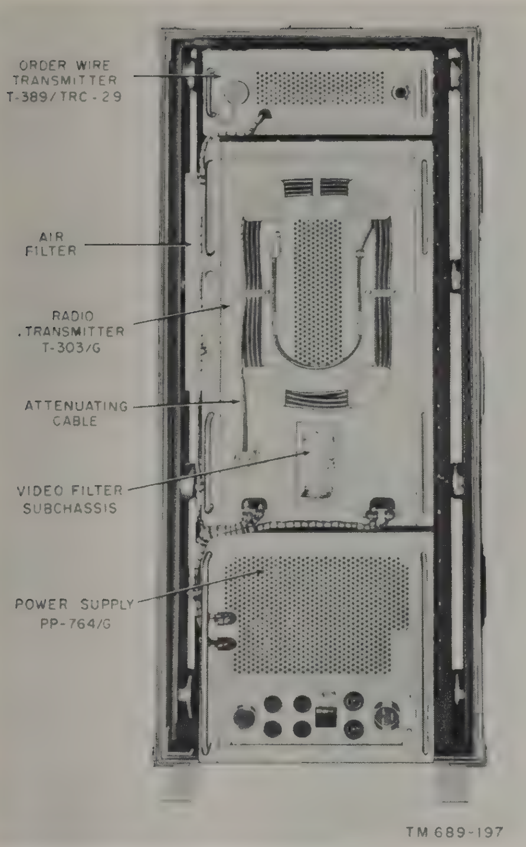


Figure 9. Transmitter rack, rear view.

covers are mounted to the top, bottom, and sides of the chassis. Handles are located on the front and rear of the chassis.

(3) The main panel of the radio transmitter is recessed and vertically positioned in the transmitter chassis. This panel supports the subchassis and assemblies that comprise the radio transmitter. The transmitter subchassis are: the meter panel, electronic voltage regulator (evr), chopper amplifier, vacuum-tube voltmeter, crystal multiplier, intermediate-frequency (if.) amplifier, modulator, and video filter. The transmitter assemblies, mounted to the main panel and sides of the chassis, are—klystron oscillator, attenuating cable, 2-slug tuner, double coupler, power amplifier assembly, triple coupler, wavemeter, afc motor, blower assembly, and air filter. These subchassis and assemblies are described in *b* through *m* below.

b. Meter Panel. The meter panel consists of a separate, hinged assembly that is located at the top front of the transmitter. The panel can be swung upward to reach the components for maintenance and repair. The rear of the panel is shielded by a perforated metal cover. Four meters and three meter selector switches are located on the panel.

c. Evr Subchassis. The evr subchassis is located in the upper left portion of the main chassis behind the meter panel. The front of the subchassis has the REFL. VOLT SUPPLY ADJ control. Connections between the evr subchassis and the radio transmitter are made through a harness from the regulator, which terminates in a 7-contact fanning strip. The strip is screw-fastened to a terminal board, which is mounted to a frame near the evr subchassis, and also connects to a helipot, REFL VOLTS ADJUST, mounted on the transmitter chassis.

d. Chopped Amplifier Subchassis. The chopper amplifier subchassis is located behind the meter panel and below the evr subchassis. The afc motor (par. 22*k*) is coupled mechanically to the fine tuning screw of the klystron. The plug-in mechanical dc to ac chopper converter is mounted on the front of the subchassis. Two relays with two microswitches on each, a component board and other components are located on the rear of the subchassis. The chopper amplifier subchassis is connected to the main chassis by two separate wire harnesses. One of these terminates in a fanning strip that is screw-fastened to a terminal board, adjacent to the subchassis. The other wire harness terminates in a Winchester plug with its receptacle located on the rear, upper center portion of the main panel.

e. Vtvm Subchassis. The vtvm subchassis consists of a rectangular chassis mounted on the front, lower left portion of the transmitter rack main panel. The vtvm input selector switch (VTVM SEL SW) is mounted to the rear of the subchassis with its shaft protruding through to the front. A bracket stamped with the switch

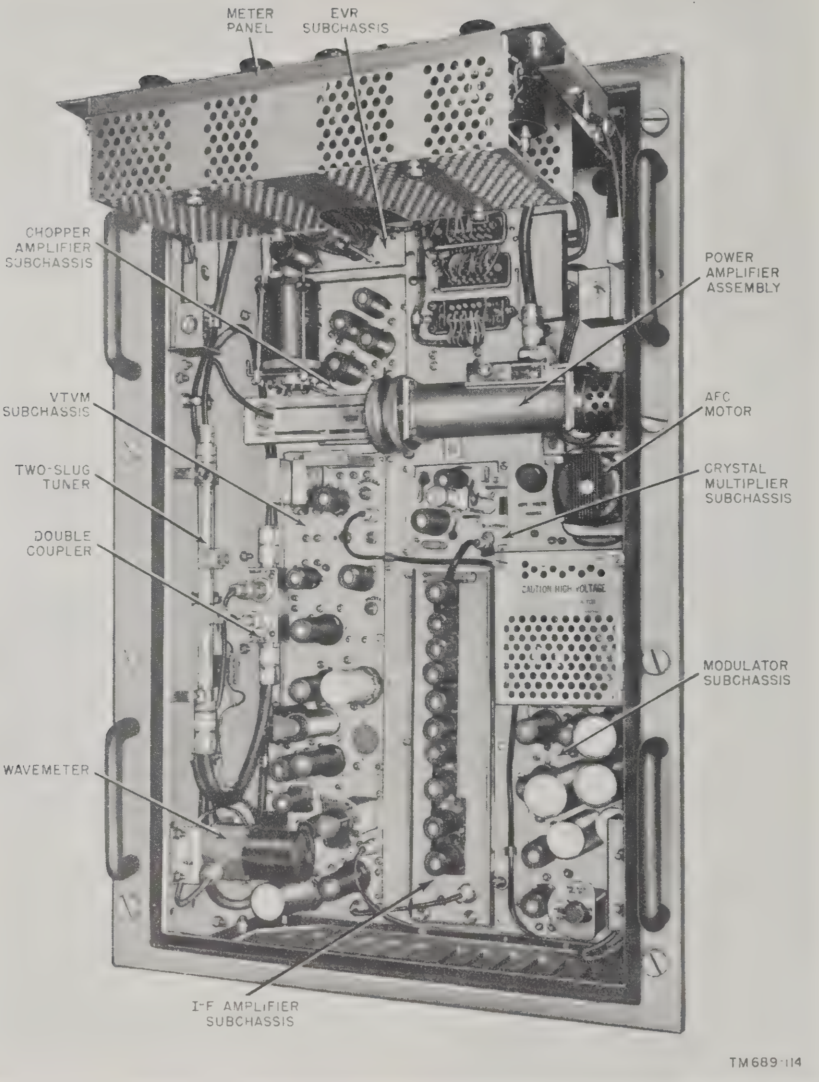

METER PANEL
EVR SUBCHASSIS
CHOPPER AMPLIFIER SUBCHASSIS
POWER AMPLIFIER ASSEMBLY
VTVM SUBCHASSIS
AFC MOTOR
TWO-SLUG TUNER
CRYSTAL MULTIPLIER SUBCHASSIS
DOUBLE COUPLER
CAUTION HIGH VOLTAGE
MODULATOR SUBCHASSIS
WAVEMETER
I-F AMPLIFIER SUBCHASSIS
TM689-114

Figure 10. Transmitter rack, oblique front view, door open and meter panel raised.

positions mounts the switch extension shaft and pointer knob. Connection to other subchassis in the transmitter rack is made through a wire harness from the rear of the vtvm subchassis, and it terminates in a fanning strip that is connected to a terminal block, mounted on the rear right side of the main panel. A cable marked MON VIDEO INPUT connects from the lower portion of the vtvm subchassis to the VIDEO OUTPUT receptacle of the if. amplifier subchassis. Receptacles marked MOD INPUT FROM MOD, MOD OUT FROM MOD, and ST OUTPUT are provided for connection to the modulator subchassis.

f. Crystal Multiplier Subchassis. The crystal multiplier subchassis is a small square chassis that is mounted on the front, center portion of the main panel of the transmitter. The four controls for the crystal multiplier are accessible from the front of the unit. A rear cover protects the components of the subchassis and acts as an electrical shield. Power for the subchassis is applied through an attached wire harness and fanning strip that is connected to a terminal board, mounted on the rear of the main panel. Connections to the other subchassis of the transmitter are made through appropriately marked receptacles on the front and rear of the crystal multiplier subchassis.

g. If. Amplifier Subchassis. The if. amplifier subchassis is a rectangular chassis, mounted below the crystal multiplier subchassis and adjacent to the vtvm subchassis. The front and rear of the if. amplifier subchassis are shielded by metal covers. A screwdriver adjustment control marked VIDEO LEVEL is located on the lower front portion of the subchassis. An rf cable from the top front of the subchassis labeled IF. INPUT connects to a receptacle on the front of the crystal multiplier subchassis marked IF. OUTPUT. A receptacle on the bottom front of the if. amplifier labeled VIDEO OUTPUT is connected to the vtvm subchassis through a short length of rf cable from the vtvm subchassis labeled MON VID INPUT. Connections to other subchassis of the transmitter are made through a wiring harness with two fanning strips from the rear of the subchassis.

h. Modulator Subchassis. The modulator subchassis is a rectangular chassis, mounted to the right front of the main panel. A cover over the output stage of the modulator subchassis protects against accidental contact with high voltage. On the front lower portion of the modulator subchassis is a three-position switch labeled MOD INPUT SEL SW and a screwdriver control marked INPUT VIDEO LEVEL. Power is supplied to the subchassis through a wire harness and fanning strip from the rear of the subchassis that connects to a terminal block, mounted on the rear of the main panel. Two receptacles on the front of the subchassis (MOD INPUT TO VTVM and ST INPUT) and a third receptacle on the rear (MOD OUT TO VTVM) connect the subchassis by suitable cables to the vtvm subchassis. Two video cables, labeled VIDEO INPUT and OW IN, located in the rear bottom portion of the subchassis, connect to approximately marked receptacles on the rear of the main panel.

i. Video Filter Subchassis. The video filter is contained in a rectangular metal box and is mounted on the rf fitting panel at the rear of the radio transmitter (fig. 9). The OUTPUT and INPUT receptacles connect to the video filter. A short length of cable is permanently attached to the OUTPUT receptacle. This cable connects into the VIDEO INPUT receptacle on rf fitting panel when the video filter is used, or to the INPUT receptacle of the video filter when it is not used. Generally, the video filter is used only at terminals or drop-channel repeater stations, and the incoming video signal is fed to the VIDEO FILTER INPUT receptacle.

j. Rf Assemblies. The various assemblies that comprise the rf section of Radio Transmitter T–303/G are located and briefly described in (1) through (7) below:

(1) *Klystron oscillator.* The klystron, when installed, is located on the left hand side of the rear of the main panel. The connection from the modulator subchassis to the klystron repeller cap and tuning controls can be reached from the front through an opening in the main panel. The fine tuning control engages the afc motor coupling (*k* below).

(2) *Attenuating cable.* The cable consists of a 10-foot length of rf cable; one end connects to the output connector of the klystron, and the other end connects to the double coupler.

(3) *Double coupler.* The double coupler is fastened to the front left hand wall of the transmitter main panel. It has three outputs: KLYSTRON POWER OUTPUT MONITOR for metering the power output of the klystron, WAVEMETER CONN for feeding a portion of the klystron output to the wavemeter, and one for feeding the klystron output to the 2-slug tuner.

(4) *Wavemeter.* The wavemeter is mounted on the lower left wall of the front of the main panel.

(5) *Slug tuner.* The slug tuner is a cylindrical unit supported vertically on

the left front wall by two standoff brackets.

(6) *Power amplifier assembly.* The power amplifier is mounted lengthwise across the upper portion of the front of the main panel.

(7) *Triple coupler.* The triple coupler is mounted on the rear left wall of the main panel. This unit is similar to the double coupler ((3) above) except that it has four outputs. The first output feeds the antenna system. The second output (AFC MIXER CONN) is connected to the crystal multiplier subchassis. The third output (PA POWER OUTPUT MONITOR) is used to indicate the power output of the power amplifier assembly. The fourth is available to make tests, and is marked –65 (TO–71) DB OUTPUT. The number used varies with each set.

k. Afc Motor. The afc motor is mounted on the main panel right front wall below the power amplifier assembly. The motor is placed so that its drive shaft couples to the klystron fine tuning adjustment. The motor shaft rotates the fine tuning adjustment. Two switches are mounted on a bracket located on the front right lower wall of the main panel: FREQUENCY INCREASE-DECREASE MANUAL TUNING and the AFC ON-OFF. In addition, two limit switches are actuated by cams on the motor shaft.

l. Blower Assembly. The blower assembly is mounted to the rear wall of the main panel above the klystron. The air outlet ducts direct streams of air over the cooling fins of the klystron and the power amplifier triode.

m. Air Filter. The air filter, mounted on the outside right side wall of the main panel, filters the air to the blower assembly air intake. The filter insert can be removed for cleaning or replacement by loosening the two knurled knobs on the frame.

23. Description of Power Supply PP–764/G

a. Power Supply PP–764/G is mounted in the lower portion of the transmitter rack (figs. 7–10). A cover frame with an access door is secured to the power supply main chassis. There are two indicator lamps at the two corner cutouts on the access door frame, one of which is labeled POWER ON and the other HV PLATE ON. Located on the front of the main chassis behind the access door are six labeled circuit breakers through which power is applied to the transmitter rack components, VARIABLE AUTOTRANSFORMER control that adjusts the variac that is contained in the power supply, and a toggle switch associated with the variac adjustment. Screwdriver adjustment BEAM V ADJ is also located on the subchassis that mounts the tubes of the power supply.

b. The power supply receptacles, convenience outlets, input circuit breakers, and convenience outlet fuses are mounted on a panel on the lower rear portion of the power supply. Above this panel, a perforated metal cover shields the components that are mounted in the rear of the power supply. When removed, the cover operates an interlock switch that removes high voltage from the transmitter. The interlock switch can be set for normal operation of the power supply with the cover removed by pulling the interlock switch rod out beyond its *off* position. Two terminal boards are located behind the cover through which connections from the power supply to other components in the rack are made.

c. Protective covers are mounted to the bottom and sides of the power supply chassis. Handles are mounted on the front and rear of the chassis.

24. Description of Receiver Rack

The receiver rack (fig. 11) consists of the transit case and the components listed in *a* through *d* below. A description of the transit case is contained in paragraph 20 and descriptions of the components are contained in paragraphs 25 through 28.

a. Order-Wire Receiver R–543/TRC–29.

b. Radio Receiver R–418/G.

c. Power Supply PP–690/G.

d. Power Supply PP–689/G.

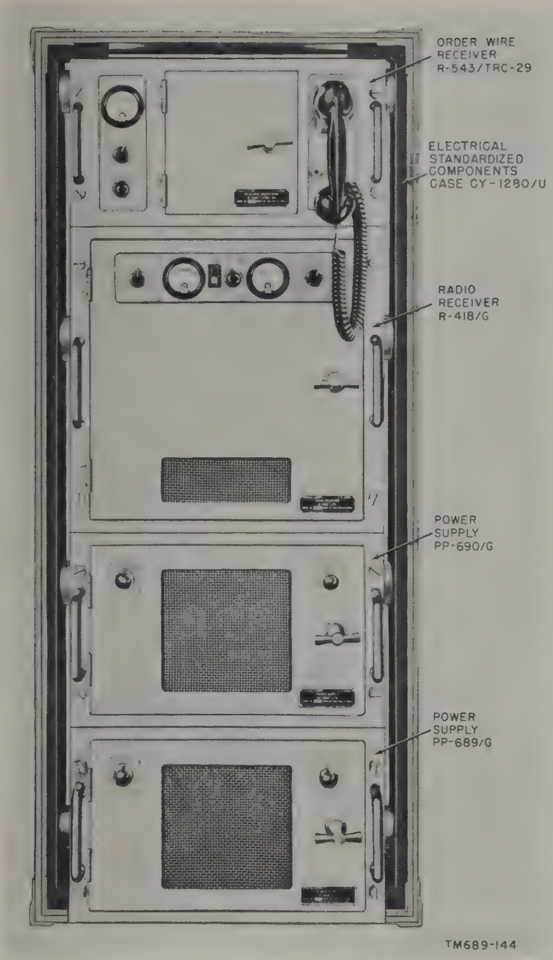

ORDER WIRE RECEIVER R-543/TRC-29
ELECTRICAL STANDARDIZED COMPONENTS CASE CY-1280/U
RADIO RECEIVER R-418/G
POWER SUPPLY PP-690/G
POWER SUPPLY PP-689/G
TM689-144

Figure 11. Receiver rack, front view.

25. Description of Order-Wire Receiver R–543/TRC–29

a. Order-Wire Receiver R–543/TRC–29 (figs. 11–13) is the top unit in the receiver rack. The front panel is covered by a removable metal cover. An access door is mounted between the two vertical cutouts that are located on each side of the frame. Framed in the left cutout are a meter and meter selector switch for obtaining readings of various circuits of the order-wire receiver, and an indicator lamp marked TRANSFER CONTROL ON that lights when transfer-control operation is used. The right cutout frames a telephone handset holder and a RING push button switch. (The handset from Handset-Signaling Unit H–102/TRC–29 is used on the order-wire receiver.) The main order-wire receiver components are mounted on a recessed panel behind the access door. Two circuit breakers, FIL and PLATE, through which filament and plate power are applied are mounted on a bracket on the right side wall. Mounted on a front panel are the BUZZER CONTROL toggle switch and SERVICE SELECTOR switch. Screwdriver controls are also mounted on the front panel. The functions of all controls are described in paragraphs 67 through 72.

b. The rear of the order-wire receiver is covered by a perforated metal cover that is secured to the chassis. The rear cover operates an interlock switch that removes all B+ power from the order-wire receiver, radio receiver, and receiver power supply when the cover is removed. The switch can be set for normal operation with the cover removed by pulling the interlock switch rod out beyond its *off* position. Connections between the order-wire receiver and other components in the receiver rack are made through a wire harness that passes through an opening in the rear cover and connects to a terminal strip on the rear of the chassis. The BUZZER PROTECTOR fuseholder is mounted below the terminal strip. Other interconnections are made through marked receptacles on the rear of the chassis.

c. Protective covers are on the top, bottom, and sides of the order-wire chassis. Handles are mounted on the front and rear.

26. Description of Radio Receiver R–418/G

a. General.

(1) Radio Receiver R–418/G is mounted below the order-wire receiver (figs. 11–14). The main panel of the radio receiver is covered by a removable gray metal cover frame that has an access door. The access door has a large cutout at the top, in which the radio receiver meter panel is framed. It has a smaller wire mesh covered cutout at the bottom for chassis ventilation. Mounted to the inside of the access door is a wavemeter frequency calibration chart.

(2) The rear of the chassis is protected by a metal cover. A duplexer can be mounted on the rear cover. Refer to

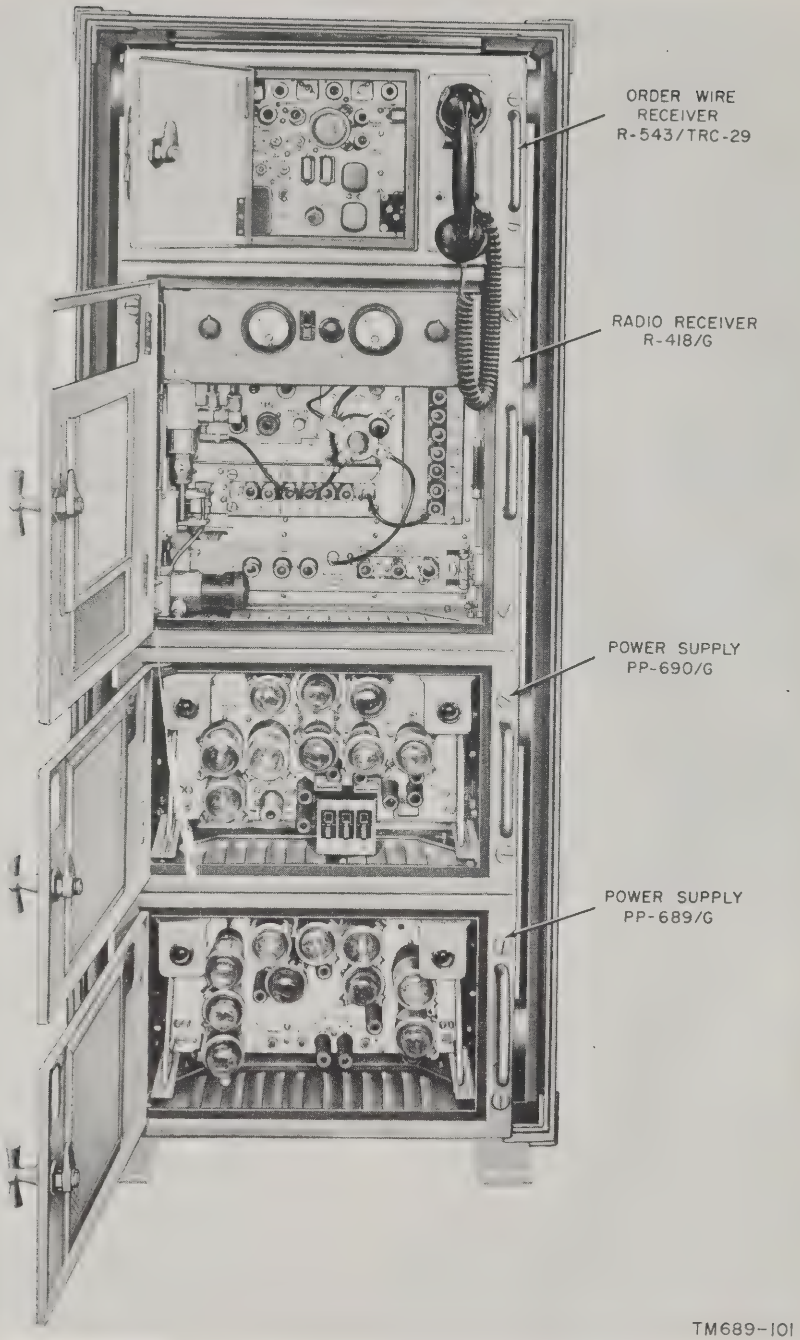

ORDER WIRE RECEIVER R-543/TRC-29
RADIO RECEIVER R-418/G
POWER SUPPLY PP-690/G
POWER SUPPLY PP-689/G
TM689-101

Figure 12. Receiver rack, front view with component access doors open.

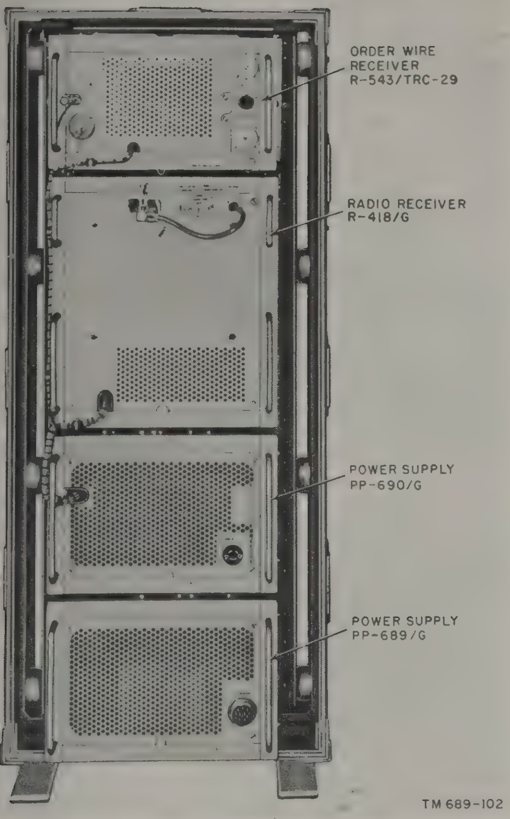


Figure 13. Receiver rack, rear view.

paragraph 33 for a description of the duplexers. Cutouts on the rear cover expose chassis receptacles and provide access to the wire harness that is used to interconnect the components in the receiver rack. The rear cover, when removed, operates an interlock switch that cuts off all B+ power to the radio receiver. The switch can be set for operation of the radio receiver with the cover removed by pulling the interlock switch rod out beyond its *off* position. Protective covers are mounted to the bottom and sides of the chassis. Handles are located on the front and rear to aid chassis removal.

(3) The main panel of the radio receiver is recessed and vertically positioned in the receiver chassis. The panel supports the subchassis and assemblies that comprise the radio receiver. The subchassis mounted to the main panel are the video amplifier, dc amplifier, if. preamplifier, if. amplifier, and afc amplifier. The assemblies mounted to the front and sides of the main panel are the local oscillator, preselector-mixer, and wavemeter. The receiver meter panel is hinged to the upper part of the main panel. Also mounted to the right side of the main panel are two hexagonal wrenches, two miniature tube pin straighteners, and an insulated tuning tool. The subchassis and assemblies are described in *b* through *j* below.

b. Description of Meter Panel. The meter panel is a separate subchassis located in the top part of the front of the radio receiver. When unfastened, the meter panel can be swung up to a horizontal position on a pair of hinges. The rear of the panel is covered by a metal shield. Two meters and two marked meter selector switches are mounted on the front panel to provide for metering of various circuits of the radio receiver. Also mounted on the front panel are the POWER circuit breaker through which power is applied to the radio receiver and the RECEIVER ON indicator lamp, which lights when power is applied to the entire radio receiver, including the order-wire receiver.

c. Description of Video Amplifier Subchassis. The video amplifier is mounted in the upper left hand part of the main panel behind the meter panel. Connections to other units on the main panel are made through a wire harness to an adjacent terminal block on the rear of the main chassis, through a short length of rf cable labeled VIDEO IN on the subchassis that connects to the VIDEO OUTPUT receptacle on the if. amplifier subchassis, and through a VIDEO OUTPUT receptacle on this subchassis that connects to output receptacles on the chassis frame labeled VIDEO OUTPUT MONITOR and VIDEO OUTPUT TO ORDER WIRE REC.

d. Description of Dc Amplifier Subchassis. The dc amplifier is mounted on the left side of the main panel below the video amplifier subchassis. Mounted on the front of the panel are the AFC switch and three screwdriver adjust controls marked IF. LEVEL, REFL V, and BEAM CURRENT. Connections to other subchassis in the radio receiver are made through a wire harness from the rear of the subchassis which connects to an adjacent terminal block.

e. Description of If. Preamplifier Subchassis. This subchassis is mounted below the dc amplifier subchassis described in *d* above. The front and rear of the subchassis are shielded by metal covers. Mounted to the front of the subchassis at one end is the PRE IF. OUTPUT receptacle, to which is connected a short length of rf cable from the if. amplifier subchassis marked IF. INPUT at the if. amplifier subchassis. Mounted on the other end of the subchassis is the PRE IF. INPUT receptacle, to which is connected a cable from the MIXER OUTPUT receptacle on the receiver preselector-mixer assembly (*i* below). Other connections to the subchassis of the radio receiver are made through a wire harness which passes through an opening in the subchassis and connects to a terminal block in the rear of the receiver main panel.

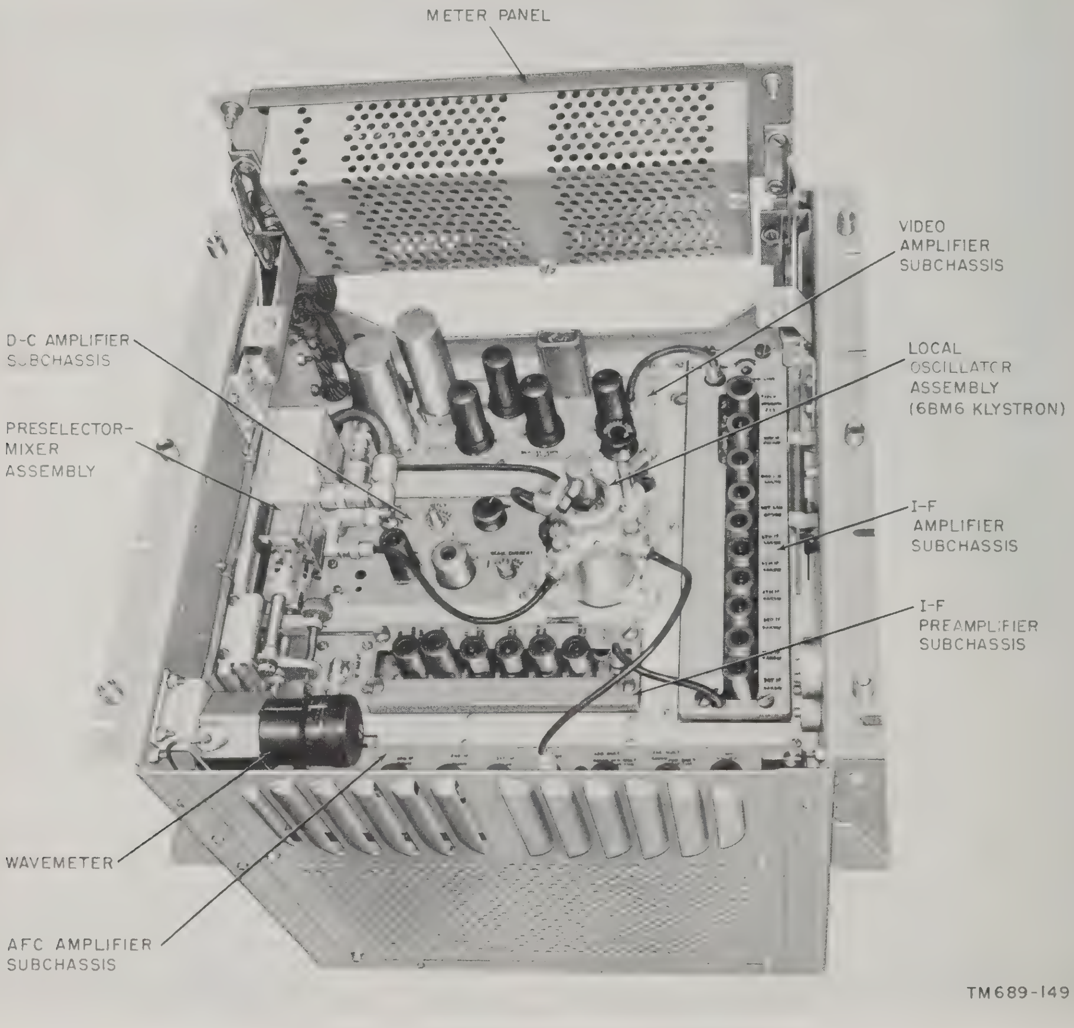

METER PANEL
VIDEO AMPLIFIER SUBCHASSIS
D-C AMPLIFIER SUBCHASSIS
LOCAL OSCILLATOR ASSEMBLY (6BM6 KLYSTRON)
PRESELECTOR-MIXER ASSEMBLY
I-F AMPLIFIER SUBCHASSIS
I-F PREAMPLIFIER SUBCHASSIS
WAVEMETER
AFC AMPLIFIER SUBCHASSIS
TM689-149

Figure 14. Receiver rack, bottom front view, meter panel swung up.

f. Description of If. Amplifier Subchassis. The if. amplifier subchassis is mounted along the right side of the receiver main panel, and it is similar in appearance to the transmitter if. amplifier subchassis.

g. Description of Afc Amplifier Subchassis. This subchassis is mounted along the lower edge of the receiver main panel. The front and rear of the subchassis are shielded by metal covers. Connections between the afc amplifier subchassis and other subchassis in the radio receiver are made with a wire harness that passes through an opening in the subchassis to a terminal block in the rear of the chassis. A receptacle marked LO INPUT on the front of the subchassis is connected through an rf cable to the klystron oscillator (local oscillator assembly).

h. Description of Local Oscillator Assembly. The local oscillator is mounted on the main panel, centrally positioned between the if. amplifier, if. preamplifier, and dc amplifier subchassis. Mounted around the front of the local oscillator assembly are the INCREASE FREQ control and three receptacles, marked WVMTR for connection to the wavemeter, MIX. for connection to the preselector-mixer subchassis, and AFC for connection to the afc amplifier subchassis.

i. Description of Preselector-Mixer Assembly. The preselector-mixer assembly is mounted on the left wall of the main panel. Three receptacles are on the upper portion of the assembly for connection to the other subchassis of the radio receiver. The LO INPUT receptacle is connected through an rf cable to the MIX. receptacle on the local oscillator assembly. The MIXER OUTPUT receptacle is connected to the PRE IF. INPUT receptacle on the if. preamplifier subchassis. The RF INPUT receptacle couples to the RF INPUT cable, which extends from the rear end of the chassis. A knurled cap marked MIXER XTAL 1N21B retains the crystal used in the subchassis.

j. Description of Wavemeter. The wavemeter is mounted on the lower portion of the left front wall of the main panel. This meter is used to check the local oscillator output frequency; it is identical with the wavemeter in the radio transmitter. Two receptacles are provided on the wavemeter; one connects to the local oscillator, and the other connects to the meter panel.

27. Description of Power Supply PP–690/G

a. The Power Supply PP–690/G chassis is mounted below the radio receiver (figs. 11–14). The front panel cover frame has a door with a large screened ventilation cutout in the center and two small corner cutouts for the POWER ON and PLATE ON indicator lights. Circuit breakers HV FIL, LV PL, and HV PL are mounted on a bracket that is located in the lower portion of the power supply. Screwdriver controls BEAM V ADJ. +250V ADJ., and +150V ADJ. are for making power supply adjustments.

b. The rear of the chassis is protected by a perforated metal cover. Removing the rear cover operates an interlock switch that cuts off all B+ voltages in the receiver, its power supply, and the order-wire receiver. The switch can be set for operation of the equipment with the cover removed by pulling the interlock switch rod out beyond its *off* position. The 115V AC INPUT receptacle can be reached through a cutout in the rear cover. Connections between the power supply, the radio receiver, and the order-wire receiver are made through a wire harness.

28. Description of Power Supply PP–689/G

a. Power Supply PP–689/G is mounted at the bottom of the receiver rack (figs. 11–13). The front panel cover frame has a door with a large screened ventilation cutout in the center and two small corner cutouts for the FIL ON and LV PLATE ON indicator lights. Screwdriver controls +250V ADJ., +150V ADJ., and +300V ADJ. are used for making power supply adjustments.

b. The rear of the chassis is protected by a perforated metal cover that operates an interlock switch when removed. The switch can be set for operation of the equipment with the cover removed by pulling the interlock switch rod out beyond its *off* position. Power Supply PP–689/G has no electrical connection to the components in the receiver rack. Connection between the power supply and the transmitter rack is made through the XMTR PWR INTERCONN receptacle on the rear. This receptacle connects through a cable to the XMTR POWER INTERCONN receptacle on Power Supply PP–764/G in the transmitter rack.

29. Description of Antenna AS–554/TRC–29

a. Antenna AS–554/TRC–29 is mounted on Tower AB–216/U, which is not supplied as part of Radio Set AN/TRC–29. The antenna is shipped in five cases (fig. 15). Follow procedures for assembling the antenna.

b. When fully assembled, the antenna consists of an 8-foot diameter paraboloid with mesh reflecting surface and a horn feed (fig. 16). The support frame that mounts the reflector to the tower is adjusted by clamps; this permits azimuth and elevation orientation of the antenna.

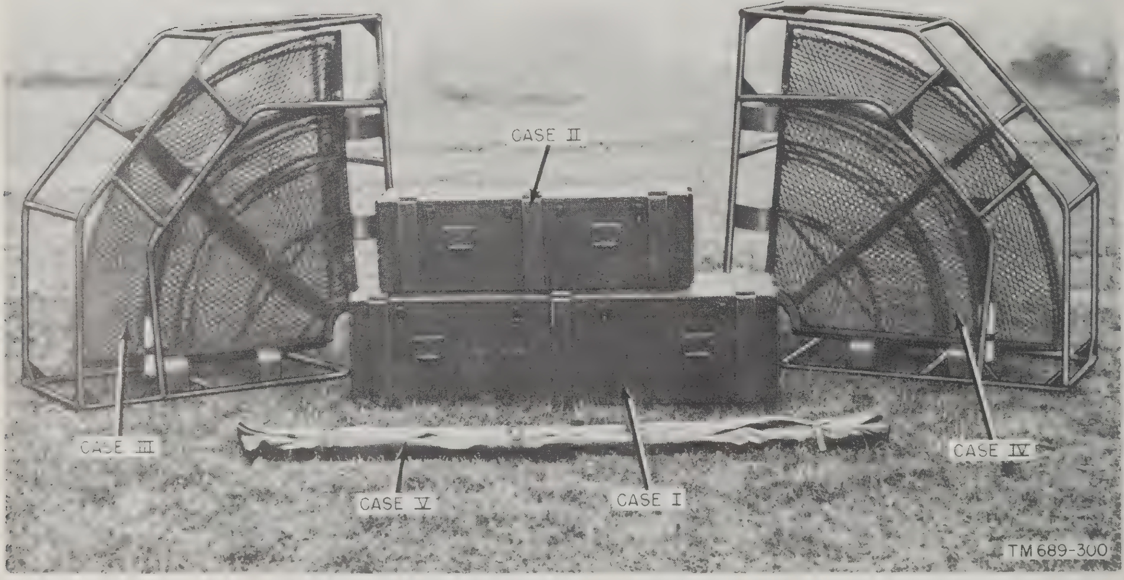


Figure 15. Antenna AS–554/TRC–29, shipping cases.

30. Radio Frequency Transmission Line Assembly CG–1013/U

a. Radio Frequency Transmission Line Assembly CG–1013/U is a surface-wave transmission line consisting of two launching units (fig. 17) connected by a low-loss, single-wire transmission line that transmits rf energy between the duplexer and the antenna. Two transmission lines are supplied.

b. The transmission line consists of 250 feet of No. 10 AWG solid copper wire with a .015-inch thick coating of polyethylene.

c. The launching unit is a conical shaped unit that couples the transmission line to the coaxial feed line at each end of the transmission line and provides an efficient transition between the transverse magnetic field on the transmission line and the transverse electric field in the coaxial feed lines. The housing contains mechanical mounting and electrical connecting devices for the transmission line, coaxial feed line, de-icing power cable, and guy assembly. The cone is waterproofed by means of a conical fiberglas shield and kept dry by a heating element inside the cone.

d. The de-icing transformer assembly provides a heating current of 40 to 60 amperes in series with the transmission line. The de-icing circuit in the launching unit is made through the Nichrome heating element to the launching unit cone and out to the other launching unit through the transmission line. The trans-

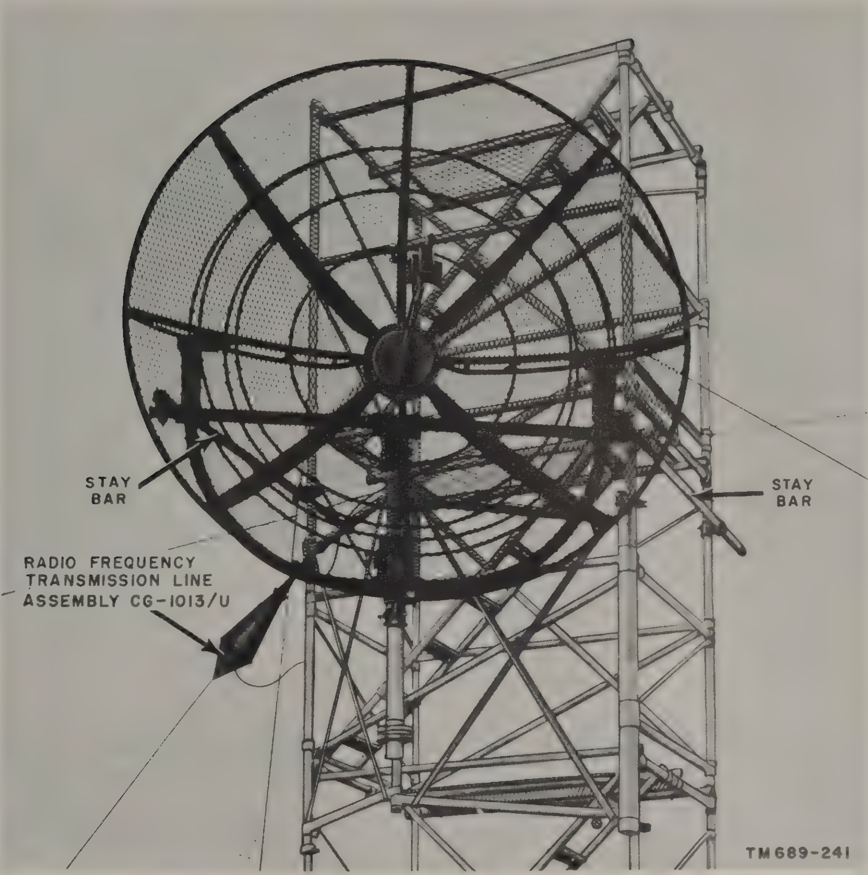


Figure 16. Antenna AS–554/TRC–29, fully assembled.

former operates from a primary voltage of 115 volts at 60 cycles per second. The secondary is tapped to provide four voltages of 10, 14, 19, and 24. An alternating current line ON-OFF switch connects power to the primary of the de-icing transformer. A 15-ampere fuse protects the de-icing transformer. The secondary current of the de-icing transformer is metered by an ammeter with a full-scale deflection of 100 amperes. A stepdown current transformer isolates the ammeter from the de-icing transformer and allows 5 amperes in its secondary for full-scale deflection when the heating current is 100 amperes.

e. The following mounting hardware is supplied:

(1) The guy assembly attaches one launching unit to walls or ground mounts, as required. It consists of a turnbuckle for tightening the guy wire, a snubit clamp for taking up slack in the guy wire, and a tensioning spring to provide tension in the guy wire.

(2) An anchor screw is supplied for normal ground mounts and a Guy Stake GP–112/G is supplied for use with frozen or extremely hard ground.

(3) A clevis is supplied to attach one launching unit to the antenna tower when Tower AB–216/U is not used. Tower AB–216/U has guy straps to be used for mounting the launching unit.

(4) An eyebolt is supplied for terminating the guy assembly through the side of a building when required.

f. The following interconnecting cables are supplied:

(1) The two rf cable assemblies are coaxial

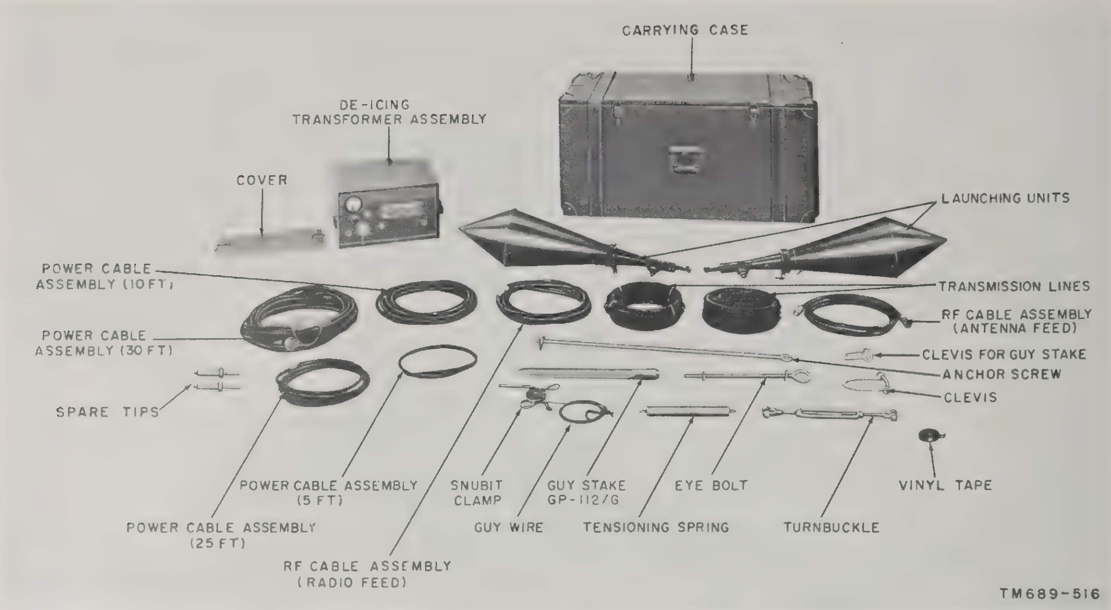
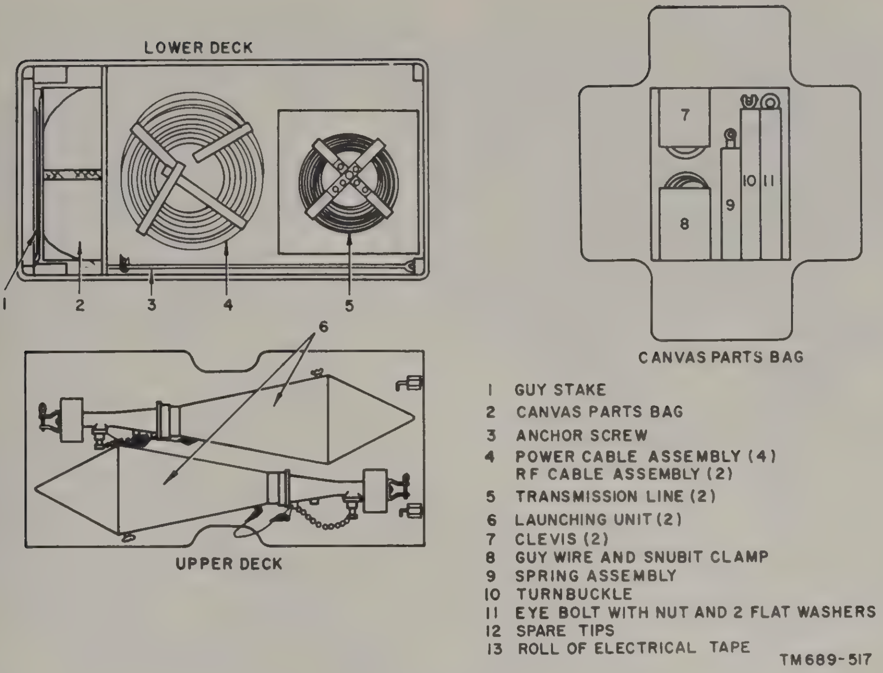

CARRYING CASE
DE-ICING TRANSFORMER ASSEMBLY
COVER
LAUNCHING UNITS
POWER CABLE ASSEMBLY (10 FT)
TRANSMISSION LINES
RF CABLE ASSEMBLY (ANTENNA FEED)
POWER CABLE ASSEMBLY (30 FT)
CLEVIS FOR GUY STAKE
ANCHOR SCREW
CLEVIS
SPARE TIPS
POWER CABLE ASSEMBLY (5 FT)
SNUBIT CLAMP
GUY STAKE GP-112/G
EYE BOLT
VINYL TAPE
POWER CABLE ASSEMBLY (25 FT)
GUY WIRE
TENSIONING SPRING
TURNBUCKLE
RF CABLE ASSEMBLY (RADIO FEED)
TM689-516

Figure 17. Radio Frequency Transmission Line Assembly CG–1013/U.

feed lines using Radio Frequency Cable RG–14/U. One end of each cable is terminated with Radio Frequency Plug UG–100A/U and the other end with Plug Connector UG–707/U. The coaxial feed line used to connect the top launching unit to the antenna is 10 feet long. The coaxial feed line that connects the radio set to the launching unit is 15 feet long.

(2) The 30-foot ac power cable connects 115-volt ac power to the de-icing transformer assembly. The 25-foot power cable connects the de-icing transformer assembly to the tower. The 10-foot power cable connects the de-icing transformer assembly to the bottom launching unit. The 5-foot power cable connects the top launching unit to the tower. All power cable assemblies, except the ac power cable, are terminated with terminal lugs.

(3) The carrying case stores all the components of Radio Frequency Transmission Line Assembly CG–1013/U except the de-icing transformer. Each component is fastened securely to the inside of the case (fig. 18). The mounting hardware, except the anchor screw and guy stake, is placed in a canvas holder and strapped into a compartment on the left side bottom of the carrying case. The anchor screw is held in place by placing its point in a hole in the compartment wall and strapping the other end to the carrying case. The guy stake is held in place by placing its clevis end in a hole at the rear of the carrying case and strapping the other end to the carrying case inside the compartment. The power and rf cable assemblies are placed on the left cable mount and held by four straps. The two transmission lines are placed on the right cable mount and held by four straps. The two launching units are mounted on the upper deck, which is held in place by two fasteners on the right. A packing diagram (fig. 18), mounted on the carrying case cover, indicates the location of the components in the carrying case.



1 GUY STAKE
2 CANVAS PARTS BAG
3 ANCHOR SCREW
4 POWER CABLE ASSEMBLY (4)
RF CABLE ASSEMBLY (2)
5 TRANSMISSION LINE (2)
6 LAUNCHING UNIT (2)
7 CLEVIS (2)
8 GUY WIRE AND SNUBIT CLAMP
9 SPRING ASSEMBLY
10 TURNBUCKLE
11 EYE BOLT WITH NUT AND 2 FLAT WASHERS
12 SPARE TIPS
13 ROLL OF ELECTRICAL TAPE

TM689-517

Figure 18. Carrying case, packing diagram.

31. Description of Minor Components of Radio Set AN/TRC–29

The minor components of Radio Set AN/TRC–29 are described below.

a. Switchbox SA–357/G. Switchbox SA–357/G (fig. 19) is a closed metal case with four outside connectors, a toggle switch, and a grounding terminal. On one side of the box are two connectors (115/230 VAC INPUT/and 115/230 VAC INPUT 2) and a toggle switch (INPUT SELECTOR SWITCH). On the other side of the box, opposite the input connectors, are the other two connectors that have the common designation 115/230 VAC OUTPUT. Below each connector is a nameplate that specifies the cable to be connected to it. At one end of the box is a terminal screw and wing nut, labeled GND CONN for the switchbox ground connection.

b. Handset-Signaling Unit H–102/TRC–29. Handset-Signaling Unit H–102/TRC–29 (fig. 20) is similar to Telephone EE–8. The unit is protected by rubber-lined canvas Telephone Set Case CY–1181/TT. On one side of the case, covered by a flap, is a ringing push button. Either Handset TS–9 (with a straight cord) or Handset H–111/U (with a coiled cord) may be supplied. The handset is stored in the canvas case with the signaling unit. At the top of the signaling unit are three terminals (T, C, and R) for the handset cord connections, and four terminals GND, XMTR, REC, and RING for line connections.

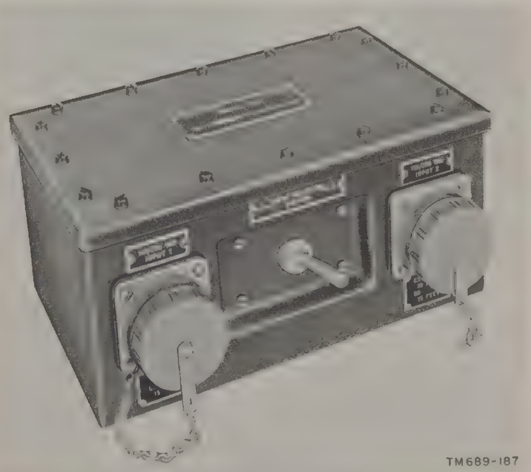


Figure 19. Switchbox SA–357/G.

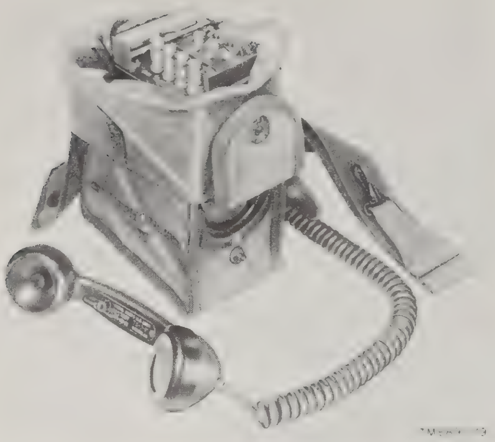


Figure 20. Handset-Signaling Unit H–102/TRC–29.

c. Fixed Autotransformer Power Transformer TF–146/G. The autotransformer is inclosed in a metal case (fig. 21). Mounted on the inclined front panel of the unit are five receptacles (115-V INPUT, 230-V INPUT, 4-KVA MAX LOAD, 115-V OUTPUT, and OUTPUT VOLTAGE TEST), and a T handle adjustment. The adjusting bar is marked INCREASE OUTPUT.

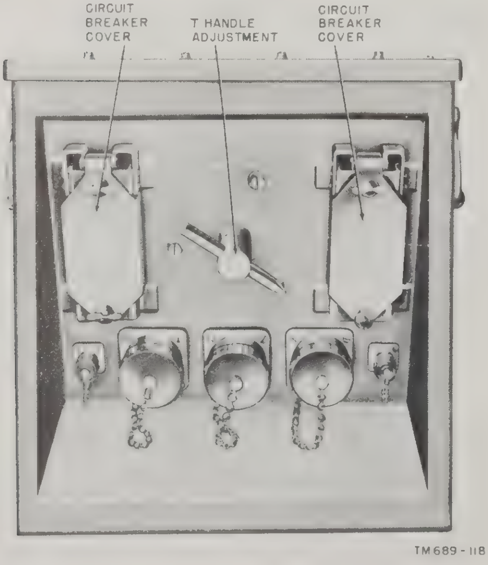


Figure 21. Fixed Auto Transformer Power Transformer TF–146/G.

32. Description of Cables Supplied with Radio Set AN/TRC–29

a. Power Cables (fig. 22).

(1) *Electrical Power Cable Assembly CX–2440/U (150 ft).* This cable assembly connects the primary ac power source to the autotransformer. It consists of a three-conductor type CO–03HGF-(3/6) 1000 cable terminated at one end by an AN 3106A–32–2S plug with cap and chain, and on the other end by an AN 3106A–32–2P plug with cap and chain. When shipped, it is wound on Reel RC–405/TR.

(2) *Electrical Power Cable Assembly CX–2440/U (15 ft).* This cable assembly connects the output of the autotransformer to the transmitter high-voltage power supply receptacle AC POWER INPUT. It is shorter than the cable assembly described in (1) above, but is otherwise identical.

(3) *Electrical Power Cable Assembly CX–2441/U (10 ft 4 in.).* This cable assembly connects primary ac power to the receiver power supply. It is connected between the 115-V AC INPUT receptacle on the receiver power supply and the REC115V AC receptacle on the transmitter high-voltage power supply. The cable assembly consists of a three-conductor type CO–03HGF-(3/14) 0560 cable terminated at one end by a Hubbell type 7555 plug, and on the other end by a Hubbell type 7572 plug.

(4) *Electrical Power Cable Assembly CX–2442/U (10 ft).* Two of these cable assemblies are supplied for connection to primary power sources. Each cable assembly consists of a three-conductor type CO–03HGF (3/6) 1000 cable terminated at one end by an AN 3106A–32–2S plug, and on the other end by three terminal lugs.

(5) *Electrical Lead CX–2683/U (20 ft).* This lead connects the GND CONN post on the switch box to the ground stake. It consists of a single-conductor type CO–01HGF (1/6) 0520 cable terminated at one end in a lug. The con-

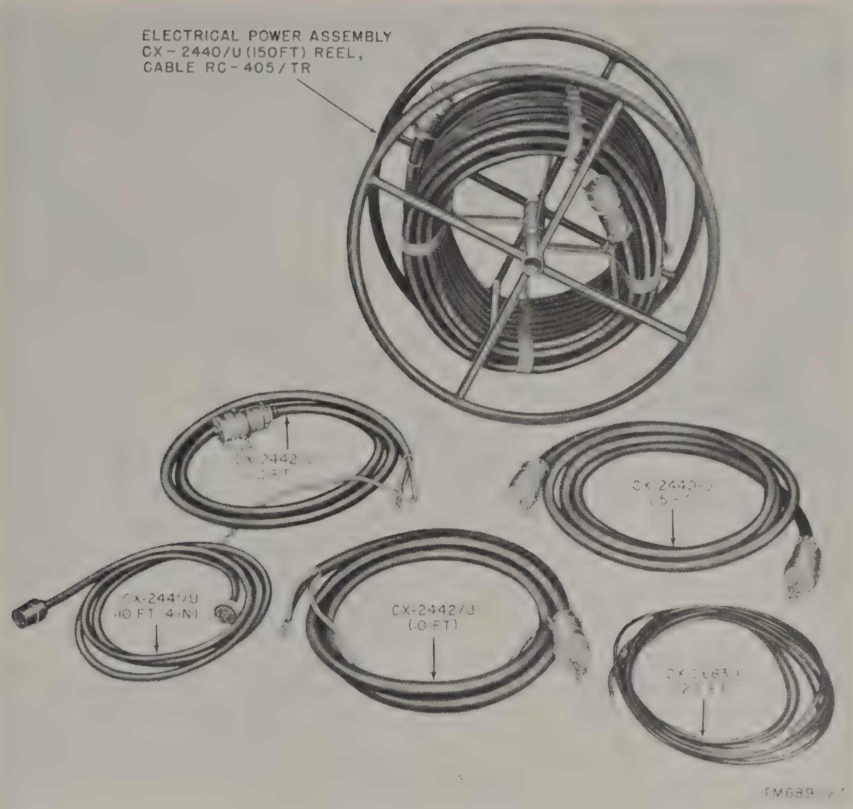


Figure 22. Radio Set AN/TRC–29, power cables.

ductor at the other end extends 3½ inches beyond the jacket and is tinned.

b. Signal Cables (fig. 23).

(1) *Electrical Power Cable Assembly CX–2443/U (15 ft).* This cable assembly connects the ORDER WIRE INTERCONN receptacle on the order-wire receiver to the ORDER WIRE INTERCONN receptacle on the order-wire transmitter. It consists of an eight-conductor type CO–06MGF(6/18)-0475 cable terminated at one end by an AN 3106B–18–8S plug with cap and chain, and on the other end by an AN 3106B–18–8P plug with cap and chain.

(2) *Electrical Power Cable Assembly CX–2444/U (25 ft).* This cable assembly connects the REPEATER INTERCONN receptacle on the east-west order-wire receiver to the REPEATER INTERCONN receptacle on the west-east order-wire receiver. It is used only in repeater stations. It consists of an 11-conductor type CO–10-HGF(10/18)0850 cable terminated at both ends by AN 3106B–24–7P plugs with caps and chains.

(3) *Electrical Power Cable Assembly CX–2445/U (10 ft).* This cable assembly connects the XMTR POWER INTERCONN receptacle on the transmitter high-voltage power supply to the XMTR POWER INTERCONN receptacle on the transmitter low-voltage power supply. It consists of a 14-conductor type CO–14HGF (4/18 – 1/18S – 1/18S – 1/18S – 1/18S – 1/18S 3/16 – 2/14) 0935 cable terminated at one end by an AN 3106B–28–2P plug with cap and chain, and on the other end by an AN 3106B–28–2S plug with cap and chain.

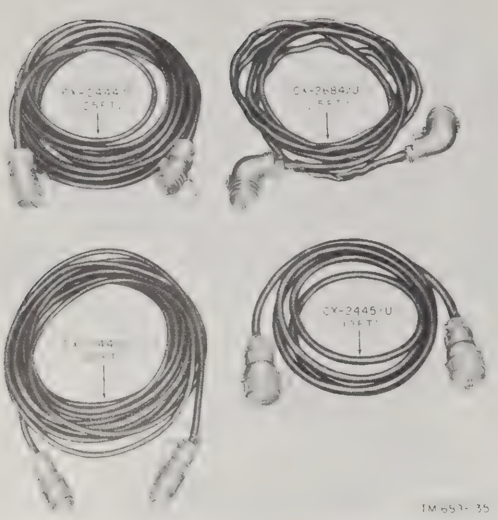


Figure 23. Radio Set AN/TRC–29, signal cables.

(4) *Electrical Power Cable Assembly CX–2684/U (15 ft).* This cable assembly connects the DIVERSITY INTERCONN receptacle on the back of one order-wire receiver to the DIVERSITY INTERCONN receptacle of the order-wire receiver used in diversity. This cable is used only for diversity operation. It consists of a 19-conductor type CO–19HGF (1/18S – 1/18S – 1/18S – 1/18S – 1/18S – 1/18S – 13/18) 0850 cable terminated at both ends by AN–3106B–28–12P plugs with cap and chain.

c. Rf Cables (fig. 24).

(1) *Cord CG–409C/U (25 ft).* Two of these cable assemblies are provided with each radio set. At a terminal or drop-channel repeater station, one is used to transmit the video signal from the video equipment output to the INPUT receptacle at the back of the radio transmitter. The other assembly is used to transmit the video signal from the VIDEO OUTPUT receptacle at the back of the order-wire receiver to the video equipment input. At a through-repeater station, one of these cables is used for each direction. In the east-west direction, it connects the VIDEO OUTPUT receptacle at the back of the east-west order-wire receiver to the VIDEO INPUT receptacle at the back of the east-west radio transmitter. In the west-east direction, connection is made between the west-east equipment. This cable assembly consists of a Radio Frequency Cable RG–58C/U terminated at each end by type UG–88/U plugs.

(2) *Cord CG–409C/U (5 ft 1 in.).* This cable is used only when the equipment is connected for diversity operation. It is connected between VIDEO INPUT FROM DIV REC receptacle on the preferred order-wire receiver to the OW CARR FILTER OUTPUT receptacle on the standby order-wire receiver. This cable assembly consists of Radio Frequency Cable RG–58C/U terminated at each end by Radio Frequency Plugs UG–88/U.

(3) *Cord CG–409C/U (2 ft 6 in.).* This cable connects the ORDER-WIRE CARRIER OUT receptacle on the order-wire transmitter to the OW INPUT receptacle on the radio transmitter. It consists of Radio Frequency Cable RG–58C/U terminated at each end by Radio Frequency Plug UG–88/U.

(4) *Cord CG/409C/U (1 ft 7 in.).* This cable connects the VIDEO INPUT FROM REC receptacle on the order-wire receiver to the VIDEO OUTPUT TO ORDER WIRE REC receptacle on the radio receiver. It consists of a type RG–58C/U coaxial cable terminated at each end by Radio Frequency Plugs UG–88/U.

(5) *Radio Frequency Cable Assembly CG–1182/U (3 ft 2 in.).* This cable connects the RF OUTPUT of the radio transmitter to either the low-band or high-band receptacle on the duplexer, depending on whether the transmitter frequency is in the low or high band. It consists of Radio Frequency Cable RG–9B/U, terminated at each end by Plug Connectors UG–573/U.

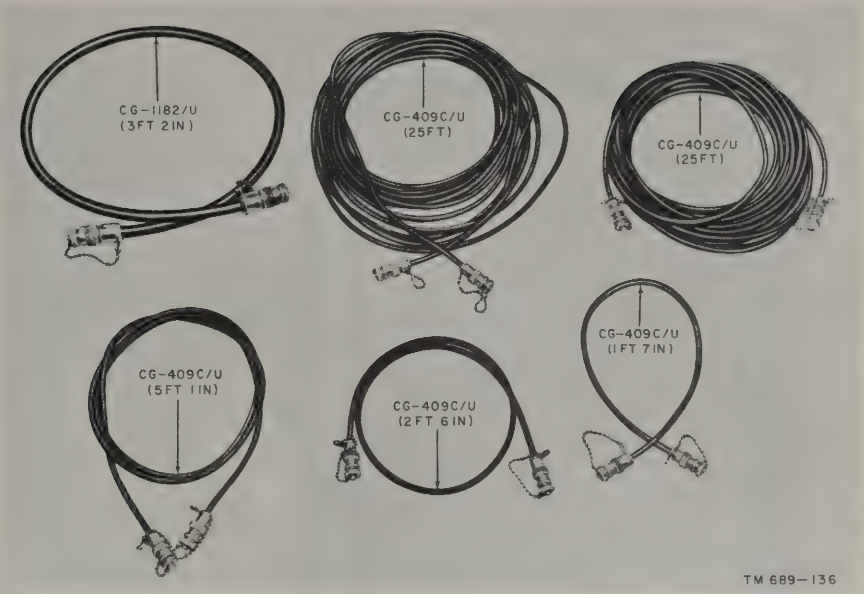

CG-1182/U
(3FT 2IN)
CG-409C/U
(25FT)
CG-409C/U
(25FT)
CG-409C/U
(1FT 7IN)
CG-409C/U
(5FT 1IN)
CG-409C/U
(2FT 6IN)
TM 689—136

Figure 24. Radio Set AN/TRC–29, rf cables.

33. Description of Special Procurement Components of Radio Set AN/TRC–29

a. General. Specific frequency control crystals, duplexers, and transmitter klystron tubes are arranged in groups, which are issued from depot stocks in accordance with each individual station's requirements as stated on the station equipment requisition. The components supplied in each of the six available groups are as follows:

(1) *Group I.*
- 2 transmitting crystals—channels 1 through 8
- 3 klystron tubes SRL7–F
- 1 Duplexer CU–368/TRC–29
- 2 receiving crystals—channels 19 through 27

(2) *Group II.*
- 2 transmitting crystals—channels 19 through 27
- 3 klystron tubes SRL7–H
- 1 Duplexer CU–368/TRC–29
- 2 receiving crystals—channels 1 through 8

(3) *Group III.*
- 2 transmitting crystals—channels 1 through 8
- 3 klystron tubes SRL7–F
- 1 Duplexer CU–368/TRC–29
- 2 receiving crystals—channels 9 through 18

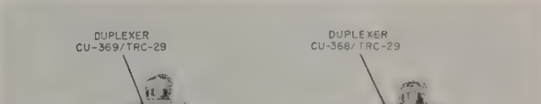

DUPLEXER
CU-369/TRC-29
DUPLEXER
CU-368/TRC-29
CHANNELS
ANTENNA
CHANNELS
20-27
ANTENNA
CHANNELS
TM 689-126

Figure 25. Duplexers CU–368/TRC–29 and CU–369/TRC–29.

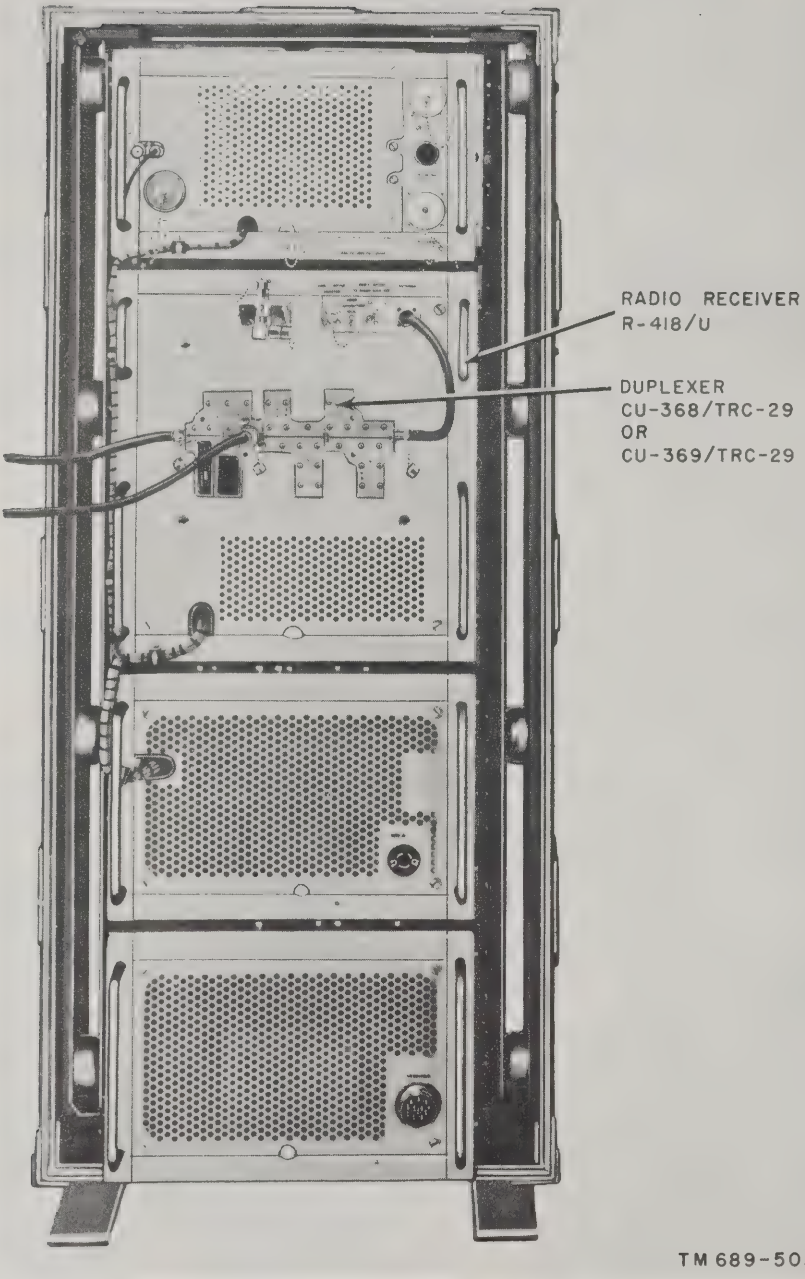

RADIO RECEIVER
R-418/U
DUPLEXER
CU-368/TRC-29
OR
CU-369/TRC-29
TM 689-502

Figure 26. Duplexer mounted on receiver rack.

(4) *Group IV.*
  - 2 transmitting crystals—channels 9 through 18
  - 3 klystron tubes SRL7–G
  - 1 Duplexer CU–368/TRC–29
  - 2 receiving crystals—channels 1 through 8

(5) *Group V.*
  - 2 transmitting crystals—channels 19 through 27
  - 3 klystron tubes SRL7–H
  - 1 Duplexer CU–369/TRC–29
  - 2 receiving crystals—channels 9 through 18

(6) *Group VI.*
  - 2 transmitting crystals—channels 9 through 18
  - 3 klystron tubes SRL7–G
  - 1 Duplexer CU–369/TRC–29
  - 2 receiving crystals—channels 19 through 27

b. Duplexer CU–368/TRC–29 (fig. 25). The duplexer permits the radio transmitter and radio receiver to connect to, and operate with, a single antenna. The duplexer includes both a high pass and a low pass section and has HIGH PASS, LOW PASS, and ANTENNA receptacles. Marked on the duplexer are its frequency characteristics. The duplexer is mounted to the rear of the radio receiver by four Dzus fasteners located on the duplexer mounting flange (fig. 26).

c. Duplexer CU–369/TRC–29 (fig. 25). Duplexer CU–369/TRC–29 is similar in appearance and operation to Duplexer CU–368/TRC–29, except for its frequency characteristics as marked on the duplexer. The selection of the proper duplexer is determined by the operating frequencies required for a particular station.

34. Running Spares and Accessories

A group of running spares and accessories are provided with each Radio Set AN/TRC–29. These components are packed in two Chests CY–250/U (case I and case II). Following is a list of all components packed in each of the two cases.

a. Spare Parts Case I (fig. 27).

Quantity	Item
6	Electron tubes, 2C51.
7	Electron tubes, 5654/6AK5W.
3	Electron tubes, 6AL5W or 5726/6AL5W.
4	Electron tubes, 6AG7.
4	Electron tubes, 6AU6.
1	Electron tube, 829B.
2	Electron tubes, 6X4W.
1	Electron tube, 2C39A.
2	Electron tubes, 807.
3	Electron tubes, OB2.
5	Electron tubes, 6AS7G.
4	Electron tubes, 5R4WGY or 5RYWGA.
2	Electron tubes, OA2.
1	Electron tube, 836.
1	Electron tube, 6J4.
1	Electron tube, 6BM6.
1	Electron tube, 5725/6AS6W.
4	Lamp, incandescent, G.E. #10C7/1 DC.
12	Fuse, cartridge 10 amp, 250 v, Bussman type No. AGC–10.
6	Fuse, cartridge ½ amp, 250 v, Bussman type No. AGC–½.
1	Tube extractor.
1	Oiler, hand.
1	Book of schematics.
1	Electrical Power Cable Assembly CX–2445/U (10 ft).
1	Electrical Power Cable Assembly CX–2440/U (15 ft).
1	Electrical Power Cable Assembly CX–2444/U (25 ft).
1	Electrical Power Cable Assembly CX–2443/U (25 ft).
2	Electrical Power Cable Assemblies CX–2442/U (10 ft).
1	Electrical Power Cable Assembly CX–2684/U (15 ft).
1	Electrical Lead CX–2683/U (20 ft).
1	Electrical Power Cable Assembly CX–2441/U (10 ft 4 in.).
2	Cords CG–409C/U (25 ft).
1	Cord CG–409C/U (1 ft 7 in.).
1	Cord CG–409C/U (2 ft 6 in.).
1	Cord CG–409C/U (5 ft 1 in.).
1	Radio Frequency Cable Assembly CG–1182/U (3 ft 2 in.).

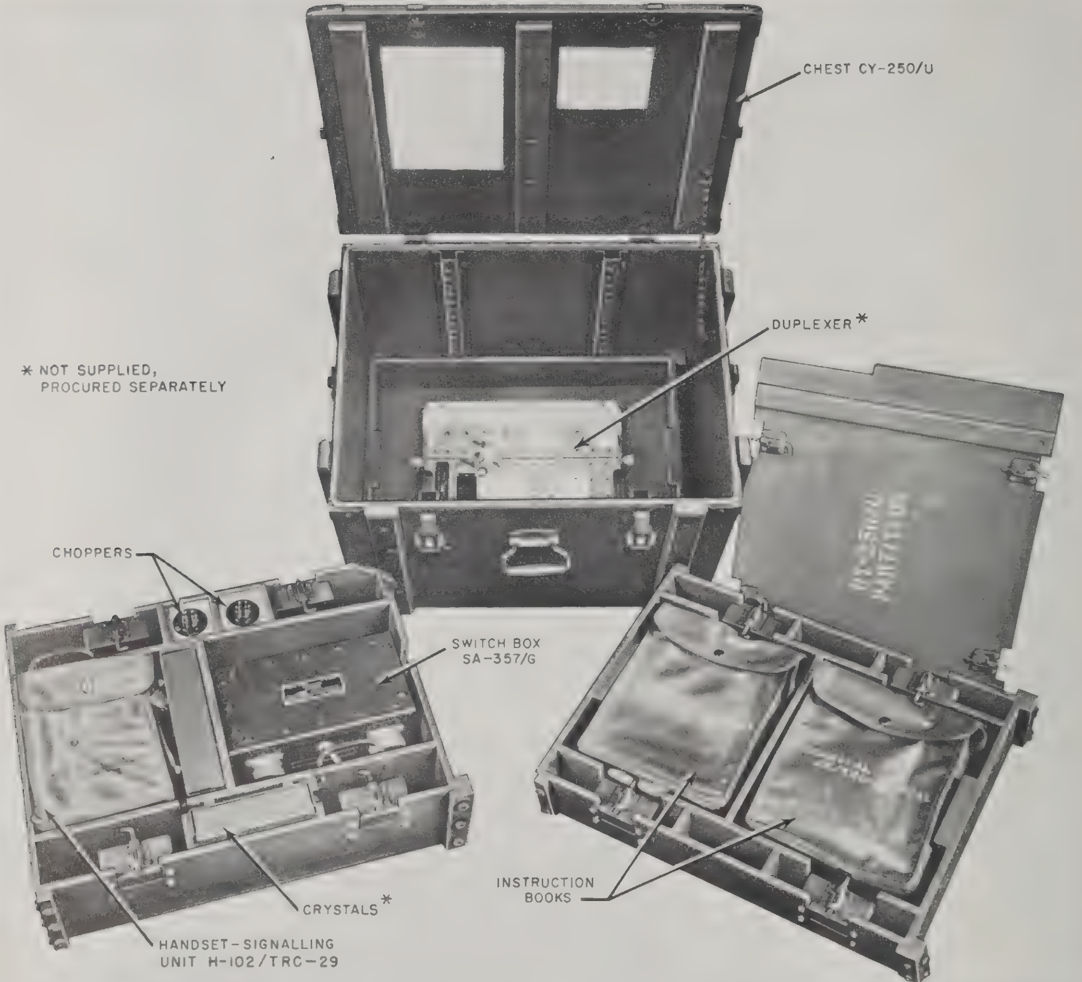

CHEST CY-250/U
DUPLEXER *
* NOT SUPPLIED, PROCURED SEPARATELY
CHOPPERS
SWITCH BOX SA-357/G
INSTRUCTION BOOKS
CRYSTALS *
HANDSET-SIGNALLING UNIT H-102/TRC-29
TM 689-497

Figure 27. Spare parts case I.

b. Spare Parts Case II (fig. 28).

Quantity	Item
1	Switchbox SA–357/G.
1	Handset-Signaling Unit H–102/TRC–29.
1	Case, crystal unit set.
2	Vibrator, synchronous dc, ac, Brown Inst. Co. No. SS–14,404-kc (1 operating, 1 spare).
1	Case, small parts:
1	Crystal unit, rectifying JAN 1N23B.
1	Crystal unit, rectifying JAN 1N21B.
1	Crystal unit, rectifying JAN 1N69.
1	Adapter Connector UG–274A/U.
2	Socket, electron tube Amphenol type No. 78–S4S.
1	Brush, General Radio Type 200B.
2	Technical manuals.

Note. This list is for general information only. See SIG 7 & 8, AN/TRC–29 for information pertaining to allowable spare parts.

35. Electrical Power Requirements

a. Radio Set AN/TRC–29 and ppm radio relay systems that use the radio set require a single-phase ac input.

b. The radio set draws 2.3 kilovolt-amperes (kva) at a power factor of better than 90 percent at a line voltage of 115. The voltage supply available to the radio set should be between 100 and 130 volts or between 200 and 260 volts at a frequency of 50 to 60 cps. This is fed through the autotransformer to deliver the required 115 volts to the transmitter-receiver equipment. The chart below lists the power requirements of Radio Set AN/TRC–29 and the ppm radio relay systems including the radio set.

Equipment	Power drain	
	Equipment (Kw)	Transmission line de-icing (Kw)
Radio Set AN/TRC–29	2.3	1
Radio Telephone Terminal Set AN/TRC–38:		
Operating equipment	3.5	1
Operating equipment and spares.	5.8	
Radio Repeater Set AN/TRC–39:		
Operating equipment	4.5	2
Operating equipment and spares.	6.8	
Radio Repeater Set AN/TRC–40:		
Operating equipment	5.3	2
Operating equipment and spares.	7.6	
Radio Repeater Set AN/TRC–41:		
Operating equipment	5.7	2
Operating equipment and spares.	8.0	

Note. All power drains listed above are nominal and are to be used only for estimating the approximate power requirements at a site. Additional power must be available for test equipment, lights, and heaters.

36. Additional Equipment Required

a. Tower AB–216/U is the only additional equipment required. It is used to mount Antenna AS–554/TRC–29, but is *not* supplied as part of Radio Set AN/TRC–29.

b. Antenna Support AB–296/G will be required at repeater stations to support diversity antennas.

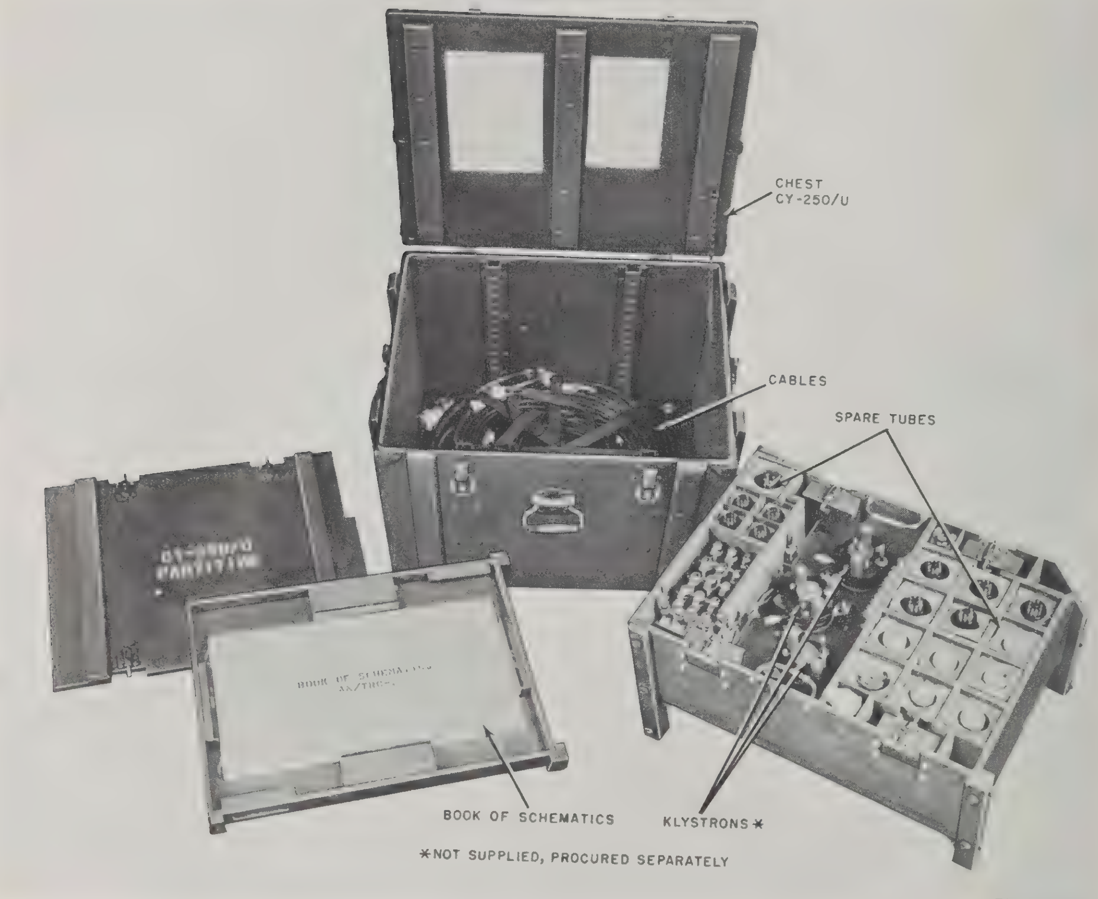

CHEST
CY-250/U
CABLES
SPARE TUBES
BOOK OF SCHEMATICS
KLYSTRONS *
*NOT SUPPLIED, PROCURED SEPARATELY
TM 689-498

Figure 28. Spare parts case II.

CHAPTER 2

INSTALLATION AND ADJUSTMENT OF RADIO RELAY SYSTEM

Section I. PLANNING RADIO RELAY SYSTEM

37. System Information Requirements

a. General. Carefully map the radio relay system, and plan all details before any equipment is obtained or installed. System information that should be known for planning is shown in *b* through *h* below.

b. Terminals. Determine the terminal points of the system. Designate one of these terminals as the east terminal, and the other as the west terminal.

c. Drop-Channel Points. Determine whether any points between the two terminals require drop-channel facilities.

d. Number of Channels. Determine the traffic requirements of the system. The ppm radio relay system can be installed to provide either 23 or 45 telephone channels.

e. Frequency Allocations. Consult the Signal Operating Instructions (SOI) or an equivalent authority, to determine whether definite frequencies have been assigned to the radio relay system. If a definite frequency assignment has not been made, determine what frequencies have been assigned in the range of 1,700 to 2,400 mc in the area to be served; then make an application for the frequencies to be used. Refer to paragraph 39 for the procedure on selecting frequencies.

f. CAA Regulations. The regulations for towers and tower lighting in the Continental United States are determined by the Civil Aeronautics Administration (CAA).

g. System Application. Determine how the radio relay system is to be used. For example whether it is a *backbone* communications system or an auxiliary to an existing system; whether it is to be used as a temporary or a permanent installation.

h. Primary Power Requirements. Determine the primary requirements for each type of station to be installed. Paragraph 35 indicates the minimum primary power requirements for Radio Set AN/TRC–29 and basic stations in a ppm radio relay system. The primary power requirements given in paragraph 35 do not include power for such accessories as lights, heaters, and similar items that are not directly involved in the actual operation of the radio equipment. Make adequate allowance for such accessories.

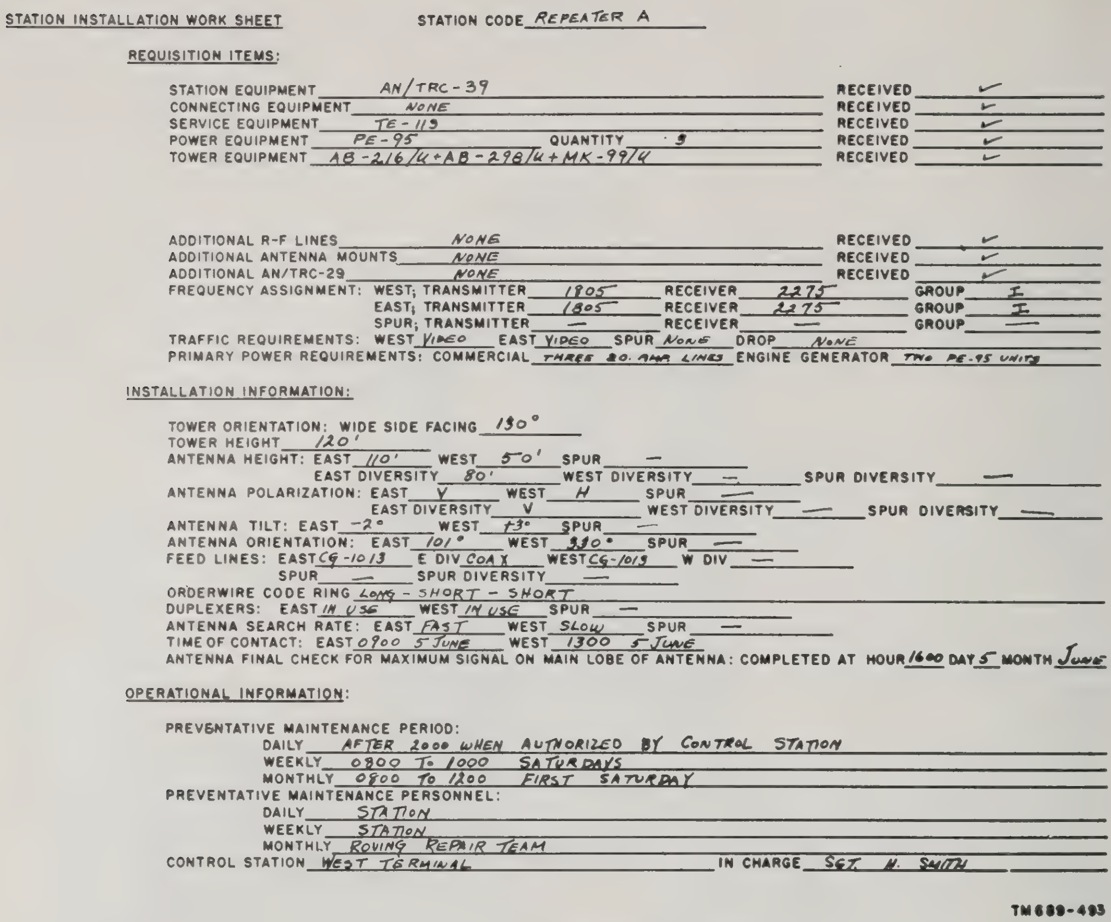
38. Station Installation Worksheet

An installation worksheet (fig. 29) should be prepared for each station in the proposed radio relay system. If the procedures outlined in paragraphs 37 through 52 are followed properly, all of the blank spaces on the first two portions of this worksheet can be filled out. Refer to chapter 4 for information in the third portion of this worksheet.

39. Selection of Operating Frequencies

a. General.

(1) Frequencies (or channels) usually are assigned to the radio relay system when the installation order is issued. However, selection of the operating frequencies must be made by personnel planning the radio link. In either case, refer to *b* through *g* below. If frequencies are assigned, be sure that they are consistent with the requirements of the radio relay system. If



STATION INSTALLATION WORK SHEET STATION CODE REPEATER A

REQUISITION ITEMS:

STATION EQUIPMENT AN/TRC-39 RECEIVED ✓
CONNECTING EQUIPMENT NONE RECEIVED ✓
SERVICE EQUIPMENT TE-113 RECEIVED ✓
POWER EQUIPMENT PE-95 QUANTITY 3 RECEIVED ✓
TOWER EQUIPMENT AB-216/U+AB-298/U+MK-99/U RECEIVED ✓

ADDITIONAL R-F LINES NONE RECEIVED ✓
ADDITIONAL ANTENNA MOUNTS NONE RECEIVED ✓
ADDITIONAL AN/TRC-29 NONE RECEIVED ✓
FREQUENCY ASSIGNMENT: WEST; TRANSMITTER 1805 RECEIVER 2275 GROUP I
EAST; TRANSMITTER 1805 RECEIVER 2275 GROUP I
SPUR; TRANSMITTER — RECEIVER — GROUP —
TRAFFIC REQUIREMENTS: WEST VIDEO EAST VIDEO SPUR NONE DROP NONE
PRIMARY POWER REQUIREMENTS: COMMERCIAL THREE 20. AMP. LINES ENGINE GENERATOR TWO PE-95 UNITS

INSTALLATION INFORMATION:

TOWER ORIENTATION: WIDE SIDE FACING 130°
TOWER HEIGHT 120'
ANTENNA HEIGHT: EAST 110' WEST 50' SPUR —
EAST DIVERSITY 80' WEST DIVERSITY — SPUR DIVERSITY —
ANTENNA POLARIZATION: EAST V WEST H SPUR —
EAST DIVERSITY V WEST DIVERSITY — SPUR DIVERSITY —
ANTENNA TILT: EAST −2° WEST +3° SPUR —
ANTENNA ORIENTATION: EAST 101° WEST 330° SPUR —
FEED LINES: EAST CG-1013 E DIV COAX WEST CG-1013 W DIV —
SPUR — SPUR DIVERSITY —
ORDERWIRE CODE RING LONG - SHORT - SHORT
DUPLEXERS: EAST IN USE WEST IN USE SPUR —
ANTENNA SEARCH RATE: EAST FAST WEST SLOW SPUR —
TIME OF CONTACT: EAST 0900 5 JUNE WEST 1300 5 JUNE
ANTENNA FINAL CHECK FOR MAXIMUM SIGNAL ON MAIN LOBE OF ANTENNA: COMPLETED AT HOUR 1600 DAY 5 MONTH June

OPERATIONAL INFORMATION:

PREVENTATIVE MAINTENANCE PERIOD:
DAILY AFTER 2000 WHEN AUTHORIZED BY CONTROL STATION
WEEKLY 0800 TO 1000 SATURDAYS
MONTHLY 0800 TO 1200 FIRST SATURDAY
PREVENTATIVE MAINTENANCE PERSONNEL:
DAILY STATION
WEEKLY STATION
MONTHLY ROVING REPAIR TEAM
CONTROL STATION WEST TERMINAL IN CHARGE SGT. H. SMITH

Figure 29. Station installation worksheet.

they are not assigned, apply for suitable frequencies. The suggestions outlined in (2) below will aid in selecting the operating frequencies.

Note. Operating frequencies must be stated on the equipment requisition before radio equipment can be ordered.

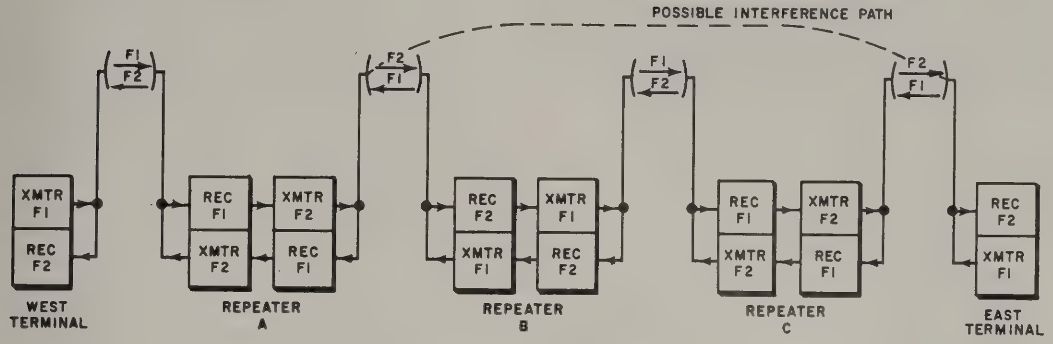
(2) Selection of operating frequencies (*e* through *g* below) is generally performed in two stages. The first stage (*b* through *d* below) involves selection of the frequency system to be used (2- or 4-frequency) and the second stage involves the selection of the actual operating frequencies.

b. Two-Frequency System.

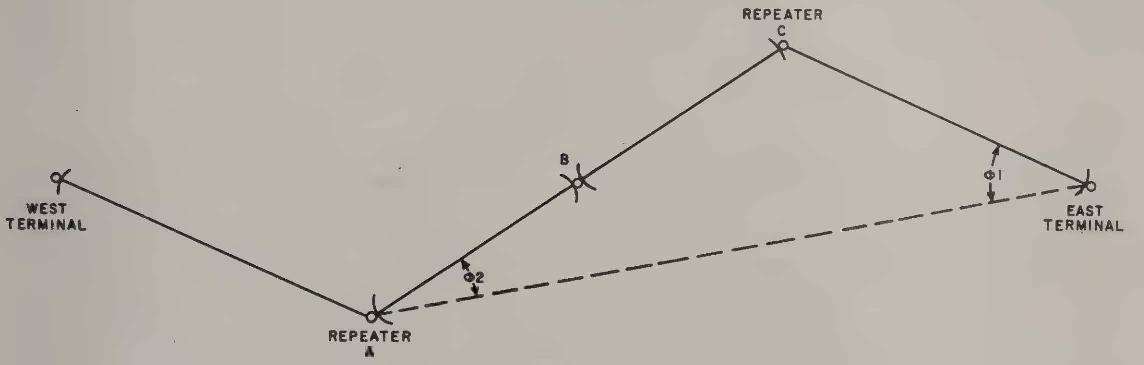
(1) In a 2-frequency system, only two frequencies, F_1 and F_2, are used for the entire link (fig. 30). For any given Radio Set AN/TRC–29, the transmitter operates on one frequency; the receiver operates at the second frequency. Transmitter and receiver frequencies are alternated for each successive station. Thus, traveling from the east to the west terminal (fig. 30), the transmitter at the east terminal operates on frequency F_1, and transmits this signal to the east-west receiver at repeater C which also operates on F_1. The output of this receiver feeds the east-west transmitter at repeater A, which operates on frequency F_2. At repeater B, the east-west receiver operates on F_2, and the

east-west transmitter on F_1. At the west terminal, the receiver operates on F_2, and the transmitter (which transmits from west to east) operates on F_1.

(2) When using a 2-frequency system, be careful to reduce the possibility of internal link interference. If all the stations are located on a geographic straight line, energy that is transmitted from the east terminal on frequency F_1 may be picked up (under certain adverse atmospheric conditions that bend the radio beam downward) by the receiver at repeater A (A, fig. 30). This causes interference with the signal coming from the east-west transmitter at repeater B.


POSSIBLE INTERFERENCE PATH
F1
F2
F2
F1
F1
F2
F2
F1
XMTR F1
REC F2
WEST TERMINAL
REC F1
XMTR F2
XMTR F2
REC F1
REPEATER A
REC F2
XMTR F1
XMTR F1
REC F2
REPEATER B
REC F1
XMTR F2
XMTR F2
REC F1
REPEATER C
REC F2
XMTR F1
EAST TERMINAL

A TWO-FREQUENCY ALLOCATION SYSTEM


REPEATER C
B
WEST TERMINAL
Φ1
EAST TERMINAL
Φ2
REPEATER A

B DOG-LEG PATH

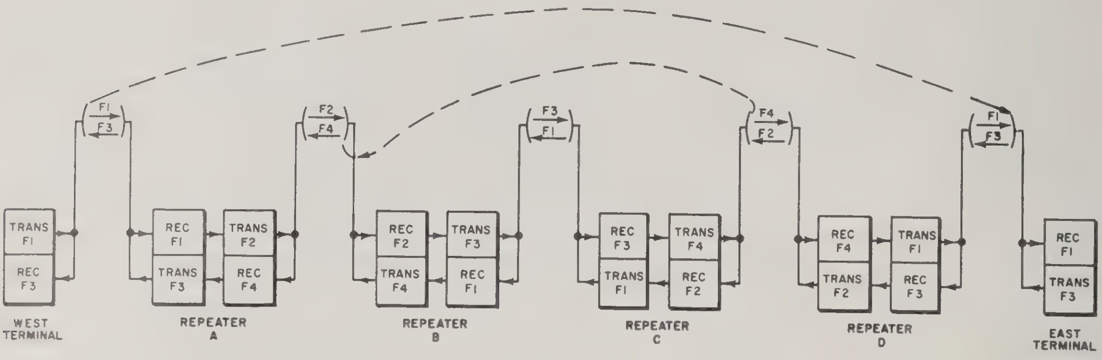
TM 689-204

Figure 30. Two-frequency system.

(3) To reduce internal interference in a 2-frequency system, the stations should be laid out in a dog-leg path (B, fig. 30), then the antenna directivity reduces the internal link interference signals. An angle ϕ_1 exists between the direction of the east terminal antenna and a straight line between the east terminal and repeater A. Similarly, an angle ϕ_2 exists between the repeater A antenna direction and this straight line. To provide sufficient unwanted signal reduction, ϕ_1 and ϕ_2 must each be greater than 10°.

c. Four-Frequency System. In a 4-frequency system, four frequencies, F_1, F_2, F_3, and F_4, are used in the radio relay link. As illustrated in figure 31, at least five hops separate a transmitter and receiver facing each other, and two hops separate a transmitter and receiver facing the same direction. Consequently, dog-legging is not ordinarily required in this system. The 4-frequency system is generally used in radio relay links with more than four hops.

d. Selection of 2-Frequency or 4-Frequency System. To conserve the frequency spectrum space the *two-frequency system should be used, if possible.* However, if the topography of a given area is not adaptable to dog-legging or dog-legging greatly increases the number of hops required, it may be necessary to use the 4-frequency system.



TM689-205

Figure 31. Four-frequency system.

e. Factors Involved in Selection of Operating Frequencies. The main factors involved in selecting the operating frequencies are as follows:

(1) *Use of channel frequencies.* Twenty-seven channel frequency crystals (*g* below) are available for use with Radio Set AN/TRC–29. Suitable groups of crystals for operation on these frequencies are issued with the equipment (par. 33). However, it is possible to operate the radio set on other frequencies if the crystals that operate on the alternate frequencies are available.

(2) *Frequency spectrum availability.* A frequency spectrum, or a definite frequency, may be used when it conforms with the following qualifications:

(*a*) Does not interfere with other systems that operate within 1,700- to 2,400-mc band.

(*b*) Is not harmonically related to the operating frequencies of other nearby systems, including radar which operates in the microwave frequency band.

(3) *Use of duplexers.* A duplexer is a standard component of Radio Set AN/TRC–29 that enables the sending of both transmitter and receiver signals over a single transmission line and antenna system. To use the duplexer in a 2-frequency system, frequency F_1 must be in the low band and F_2 must be in the high band. In a 4-frequency system, F_1 and F_3 must be in the low band and F_2 and F_4 must be in the high band. The chart below tabulates the frequency bands that are available for each duplexer. The band frequency ranges differ for the two types of duplexers. If the assigned frequencies are such that neither duplexer can be used, the equipment must be operated without one.

Type of duplexer	Low band F_1 and F_3*	High band F_2 and F_4*
CU–368/TRC–29	1,700 to 1,933 mc Channels 1 through 8.	2,050 to 2,400 mc Channels 15 through 27.
CU–369/TRC–29	1,700 to 2,050 mc Channels 1 through 14.	2,165 to 2,400 mc Channels 20 through 27.

*Used in four-frequency systems only.

f. Frequency Selection Charts. Figures 32 (with duplexer) and 33 (without duplexer) are frequency charts that indicate all possible frequency channel combinations that can be used in a 2-frequency system. Some channels which may appear usable from a study of duplexer ranges are deleted for the same reasons as those stated in (2) below. These charts are used as follows:

(1) *Installations using duplexers.* In the chart (fig. 32), all boxes marked X indicate frequency combinations that *cannot* be used; all boxes marked A indicate frequency combinations that can be used *only* with Duplexer CU–368/TRC–29. All boxes marked B indicate frequency combinations that can be used *only* with Duplexer CU–369/TRC–29, and boxes marked AB indicate frequency combinations that can be used with either Duplexer CU–368/TRC–29 or Duplexer CU–369/TRC–29. Thus, if F_1 is chosen to be channel 1, then F_2 *cannot* be channels 2 through 14; F_2 *can* be channels 15 through 19 only when Duplexer CU–368/TRC–29 is used, and can be channels 20 through 27 when either Duplexer CU–368/TRC–29 or CU–369/TRC–29 is used.

(2) *Installations not using duplexers.* In the chart (fig. 33), all boxes marked X indicate frequency combinations that *cannot* be used, and all blank boxes indicate frequency combinations that *can* be used. Channel pairs are unusable if they have image frequency, adjacent channel, or half if. separation relationship. Thus, if F_1 is chosen as

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
1																											
2	X																										
3	X	X																									
4	X	X	X																								
5	X	X	X	X																							
6	X	X	X	X	X																						
7	X	X	X	X	X	X																					
8	X	X	X	X	X	X	X																				
9	X	X	X	X	X	X	X	X																			
10	X	X	X	X	X	X	X	X	X																		
11	X	X	X	X	X	X	X	X	X	X																	
12	X	X	X	X	X	X	X	X	X	X	X																
13	X	X	X	X	X	X	X	X	X	X	X	X															
14	X	X	X	X	X	X	X	X	X	X	X	X	X														
15	A	A	A	A	X	A	A	A	X	X	X	X	X	X													
16	A	A	A	A	X	X	A	A	X	X	X	X	X	X	X												
17	A	A	A	A	A	X	X	A	X	X	X	X	X	X	X	X											
18	A	A	A	A	A	A	X	X	X	X	X	X	X	X	X	X	X										
19	A	A	A	A	A	A	A	X	X	B	B	B	B	B	X	X	X	X									
20	AB	AB	AB	AB	AB	AB	AB	AB	X	X	B	B	B	B	X	X	X	X	X								
21	AB	AB	AB	AB	AB	AB	AB	AB	B	X	X	B	B	B	X	X	X	X	X	X							
22	AB	AB	AB	AB	AB	AB	AB	AB	B	B	B	X	X	B	X	X	X	X	X	X	X						
23	AB	AB	AB	AB	AB	AB	AB	AB	B	B	B	B	X	X	X	X	X	X	X	X	X	X					
24	AB	AB	AB	AB	AB	AB	AB	AB	B	B	B	B	B	B	X	X	X	X	X	X	X	X	X				
25	AB	AB	AB	AB	AB	AB	AB	AB	B	B	B	B	B	B	X	X	X	X	X	X	X	X	X	X			
26	AB	AB	AB	AB	AB	AB	AB	AB	B	B	B	B	B	B	X	X	X	X	X	X	X	X	X	X	X		
27	AB	AB	AB	AB	AB	AB	AB	AB	B	B	B	B	B	B	X	X	X	X	X	X	X	X	X	X	X	X	

NOTE
INTERSECTIONS WITHOUT X'S INDICATE USABLE PAIRS OF CHANNEL ASSIGNMENTS
A. DUPLEXER CU-368/TRC-29
B. DUPLEXER CU-369/TRC-29
AB. EITHER CU-368/TRC-29 OR CU-369/TRC-29

TM 689-206

Figure 32. Frequency selection chart, with duplexer.

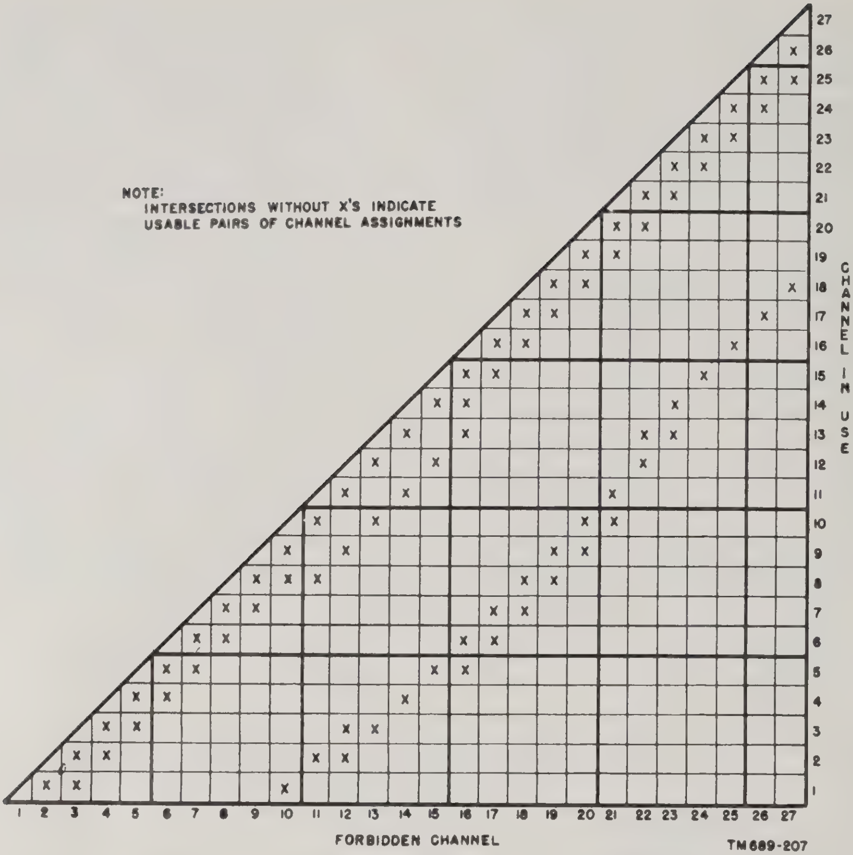


Figure 33. Frequency selection chart, without duplexer.

channel 1, F_2 can be any other channel but 2, 3, or 10.

g. Channel Frequencies. The table in (4) below lists the carrier, local oscillator, transmitter crystal, and receiver crystal frequencies for the 27 channels that are assigned to Radio Set AN/TRC–29. The following equations are used to determine local oscillator and crystal frequencies from the carrier frequency:

(1) *Local oscillator frequency.* Local oscillator frequency = carrier frequency (in mc) —120 mc.

(2) *Transmitter crystal frequency.*

(*a*) *For carrier frequencies from 1,700 to 1,900 mc*

$$\text{Transmitter crystal frequency (in mc)} = \frac{\text{carrier frequency} + 120}{24}$$

(*b*) *For carrier frequencies from 1,900 to 2,400 mc*

$$\text{Transmitter crystal frequency (in mc)} = \frac{\text{carrier frequency} + 120}{30}$$

(3) *Receiver crystal frequency.*

(*a*) *For carrier frequencies from 1,700 to 2,034.5 mc*

$$\text{Receiver crystal frequency (in mc)} = \frac{\text{carrier frequency} + 85.5}{40}$$

(*b*) *For carrier frequency from 2,034.5 to 2,400 mc*

$$\text{Receiver crystal frequency (in mc)} = \frac{\text{carrier frequency} + 85.5}{48}$$

(4) *Table of channel frequency allocation.* The following is a table of channel and crystal frequencies in mc.

Chan No.	Carrier	Xmtr crystal	Rcvr crystal	Local osc	Chan No.	Carrier	Xmtr crystal	Rcvr crystal	Local osc
1	1,715	76.458	45.013	1,835	14	2,040	72.000	44.281	2,160
2	1,745	77.708	45.763	1,865	15	2,065	72.833	44.802	2,185
3	1,775	78.958	46.513	1,895	16	2,090	73.667	45.323	2,210
4	1,805	80.208	47.263	1,925	17	2,115	74.500	45.844	2,235
5	1,835	81.458	48.013	1,955	18	2,140	75.333	46.365	2,260
6	1,860	82.500	48.638	1,980	19	2,165	76.167	46.885	2,285
7	1,885	83.542	49.263	2,005	20	2,190	77.000	47.406	2,310
8	1,910	67.667	49.888	2,030	21	2,215	77.833	47.927	2,335
9	1,935	68.500	50.513	2,055	22	2,245	78.833	48.552	2,365
10	1,960	69.333	51.138	2,080	23	2,275	79.833	49.177	2,395
11	1,980	70.000	51.638	2,100	24	2,310	81.000	49.906	2,430
12	2,000	70.667	52.138	2,120	25	2,335	81.833	50.427	2,455
13	2,020	71.333	52.638	2,140	26	2,360	82.667	50.948	2,480
					27	2,385	83.500	51.469	2,505

40. Factors Affecting Microwave Propagation

a. Introduction. When planning the radio relay system, it is necessary to know the principal factors that affect the propagation of microwave energy (at 2,000 mc) between two points on the earth surface. These factors can be classified under three major headings ((1) through (3) below). A more detailed description of these factors is given in *b* through *d* below.

(1) *Free-space attenuation.* Microwave energy that is transmitted into free space is propagated in a beam, the diameter of which increases (just as a light beam transmitted by an automobile headlight increases) as the distance from the transmitting antenna increases. Only a small portion of the energy that is contained in this beam is picked up by the receiving antenna; the diameter of this antenna is much smaller than the beam diameter. The remainder of the energy is lost in free space. The ratio of transmitted-to-received signal due to this factor is known as the free-space attenuation of the microwave signal.

(2) *Topographical factors.* Obstacles, such as hills or buildings, may intercept part of the beam and modify its transmission. The beam may also be reflected from smooth surfaces, such as water, and cause a second transmission path. The signal that takes the second path may in turn modify the original signal that follows the first path. (The first transmission path is the direct path between the two points.)

(3) *Atmospheric factors.* A variety of atmospheric conditions may cause the beam to bend upward or downward and thus modify the value of the received signal.

b. Free-Space Attenuation.

(1) The free-space attenuation increases as the distance between the antennas increases, and decreases as the size of the antennas and the frequency increases. In the radio relay system that uses Radio Set AN/TRC–29, the antenna size is fixed at 8 feet and the frequency is about 2,000 mc. Therefore, the prime factor that affects the free-space attenuation in this system is the distance between antennas.

(2) In this manual, the path attenuation between two stations is defined as the ratio between the transmitter output and the receiver input signal strengths. Free-space attenuation is the principal factor that determines the path attenu-

ation. Other contributing factors are losses in transmission lines and insertion losses at the duplexer. In a 30-mile path that uses 200-foot towers, the total attenuation is 84.5 db.

(3) Figure 34 plots the variation in path attenuation with distance for a Radio Set AN/TRC–29 system that uses 200-foot antenna transmission lines. The path attenuation decreases by 6 db each time the path distance is halved, and increases by 6 db each time it is doubled. Thus, a 15-mile path has an attenuation of 78.5 db, and a 60-mile path has an attenuation of 90.5 db. The path attenuation decreases for shorter transmission lines at the rate of 1 db per 100 feet. Thus, if 100-foot transmission lines, instead of 200-foot, are used in a 30-mile path, the attenuation is 82.5 db (1 db less for each transmission line).

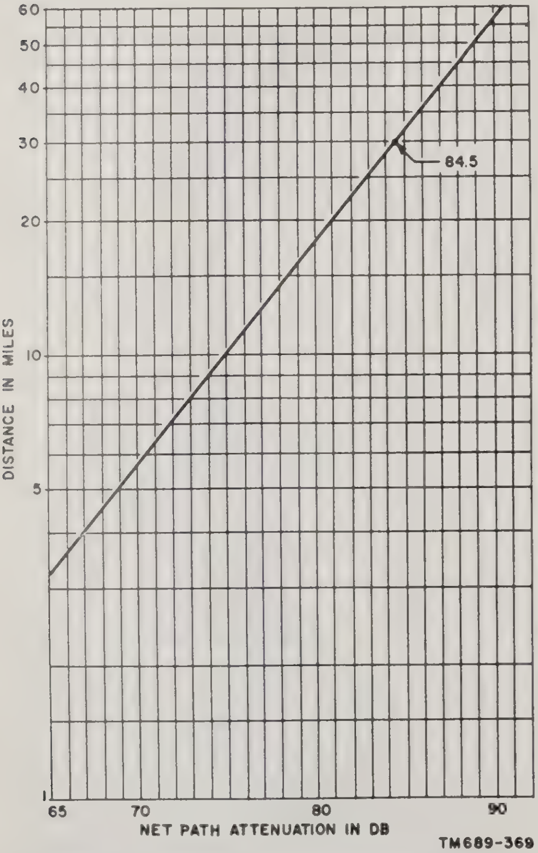


Figure 34. Net path attenuation versus distance.

c. Topographical Factors.

(1) *Major obstacles.* The major obstacles for single paths are topographical elements, such as hills, ridges, solid rows of trees, and buildings. For perfectly smooth earth, the natural spherical contour of the earth surface is an obstacle if one of the antennas is below the horizon. Be sure that major obstacles do not intercept the direct optical path. An adequate clearance, the first Fresnel zone clearance, must be allowed for the optical line of sight.

(2) *First Fresnel zone clearance.*

(*a*) The amount of clearance that is required over all obstacles and terrain is called the first Fresnel zone clearance. This zone between any two stations (T and R, fig. 35) is inclosed in the ellipsoid. The radius of the first Fresnel zone F_r, at any point P_1, located d_1 from T and d_2 from R, is given by the following equation:

$$F_r \text{ (in feet)} = 2{,}280 \sqrt{\frac{d_1 \times d_2}{F\ (d_1 + d_2)}},$$

where d_1 and d_2 are expressed in miles and F (frequency of operation) in mc.

(*b*) At a frequency F = 2,000 mc, this equation reduces to:

$$F_r \text{ (in feet)} = 51 \sqrt{\frac{d_1 \times d_2}{d_1 + d_2}}$$

(*c*) The equation ((*b*) above) gives a good approximation of the Fresnel zone clearance that is required for operation on any channel of Radio Set AN/TRC–29. When the exact clearance must be known (in paths where the clearance is just barely made or missed), the equation ((*a*) above) should be calculated with the exact channel frequency for F.

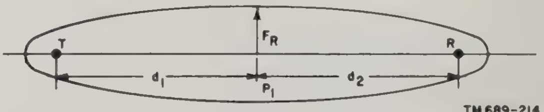


Figure 35. Fresnel zone ellipsoid.

(3) *Minor obstacles.* Minor obstacles, such as isolated tree trunks or telephone poles, have little effect on transmission if they are located over 200 feet away from the antenna. However, within 200 feet, such obstacles can intercept an appreciable portion of the beam and cause spurious responses between two antennas that are mounted on the same tower. Therefore, whenever possible, the beam path should be clear of all obstacles within a solid angle of 40°, up to a distance of at least 200 feet (fig. 36).

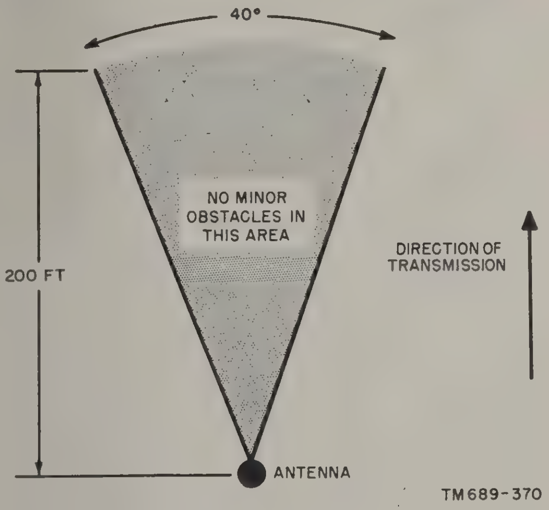

40°
200 FT
NO MINOR OBSTACLES IN THIS AREA
DIRECTION OF TRANSMISSION
ANTENNA
TM689-370

Figure 36. Minor obstacle clearance area.

(4) *Reflecting surfaces.*

(*a*) *General.* The microwave beam can be reflected from certain surfaces ((*b*) through (*d*) below) just as light is reflected from a mirror. This type of reflection results in multipath reception (fig. 37), which may cause severe fading.

(*b*) *Overland paths.* Irregular terrain, such as rolling countryside, is generally most suitable for minimizing the effects of reflection paths. Smooth terrain, such as salt flats, should be avoided. However, if it is necessary to use such paths, a high-low type of siting or a screening technique (fig. 38) should be employed, if possible. This high-low technique requires one site highly elevated to provide the required clearance at midpath, and the other site 6 to 8 feet above ground level. If these techniques cannot be used, resort to diversity reception (par. 42).

(*c*) *Overwater paths.*

1. Overwater paths should be avoided because of the possibility of a reflected signal. When such a path must be used, the high-low technique may again be useful. One site is highly elevated; the other site is a few feet above ground, so that the reflection point occurs on the land portion of the path (fig. 39). When planning such a path, the line-of-sight clearance must be obtained.

2. When the profile of the path per-

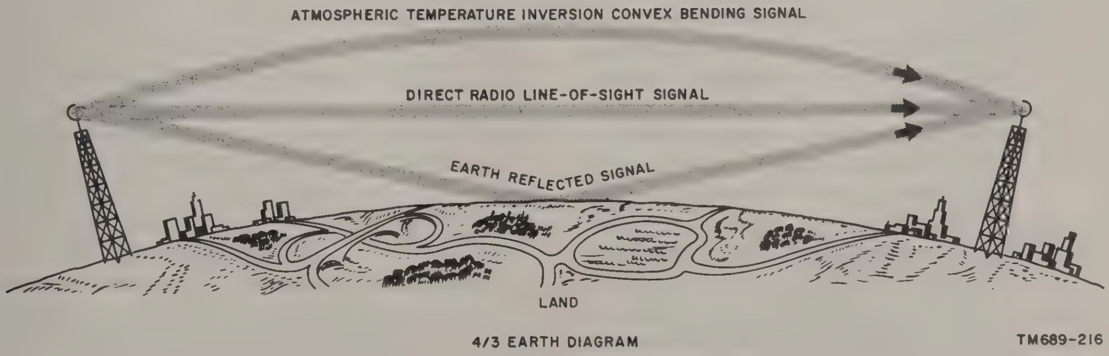

ATMOSPHERIC TEMPERATURE INVERSION CONVEX BENDING SIGNAL
DIRECT RADIO LINE-OF-SIGHT SIGNAL
EARTH REFLECTED SIGNAL
LAND
4/3 EARTH DIAGRAM
TM689-216

Figure 37. Multipath transmission.

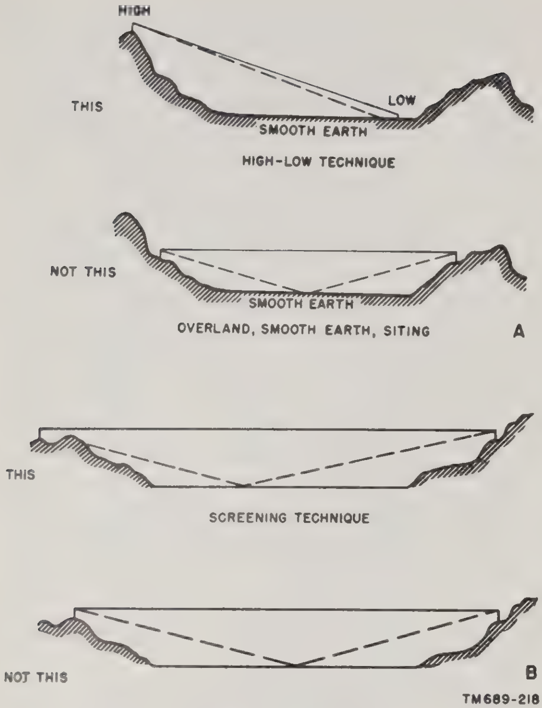

HIGH
THIS
LOW
SMOOTH EARTH
HIGH-LOW TECHNIQUE
NOT THIS
SMOOTH EARTH
OVERLAND, SMOOTH EARTH, SITING
A
THIS
SCREENING TECHNIQUE
NOT THIS
B
TM689-218

Figure 38. Siting for overland paths.

mits, the screening technique (B, fig. 38) should be used. The high contour that serves as the screen must still have the required Fresnel zone clearance. However, it may be possible to provide sufficient clearance, and yet block out the reflected signal.

3. By attenuating the reflected signal (*1* and *2* above), the reliable communications that are required in many locations may be provided. When fading still exists or these techniques are not practical because of the terrain, diversity reception must be used (par. 42).

(*d*) *Highly elevated paths.* Avoid a highly elevated path (one in which the path clearance is many times the required first Fresnel zone clearance). One method of avoiding this type of path is to use the high-low technique (fig. 38). Another method is to select sites at lower elevations, which provide the path lengths that are required. If these methods are not possible, diversity reception may be required.

(*e*) *Atmospheric factors.*

1. *Beam bending* (fig. 40).

(a) Normally, both the density and temperature of the lower atmosphere drop with height. This causes a microwave beam to bend gradually toward the earth surface (convex bending), as it travels through the lower atmosphere (fig. 37). Under normal conditions, the convex path that is followed by the microwave beam (known as the radio line-of-sight path) increases the earth radius by 4/3. Therefore, a 4/3 earth radius is used when checking the line of sight of a path.

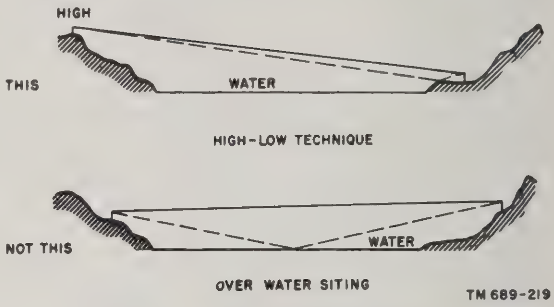

HIGH
THIS
WATER
HIGH-LOW TECHNIQUE
NOT THIS
WATER
OVER WATER SITING
TM 689-219

Figure 39. Siting for overland paths.

(b) The fall of temperature with height is unusually rapid, and an abnormal amount of convex bending occurs (fig. 40). The reverse can occur at other times, and the beam will bend away from the earth (concave bending). Under the latter conditions, the beam may be intercepted by an obstacle unless full first Fresnel zone clearance (*c*(2) above) is provided.

2. *Multipath propagation in upper atmosphere.* Microwave signals, under certain atmospheric conditions, can be refracted or reflected from the upper atmosphere (fig. 37). Such multipath transmission may cause severe fading. It may be necessary to use diversity reception (par. 42), if it occurs very often.

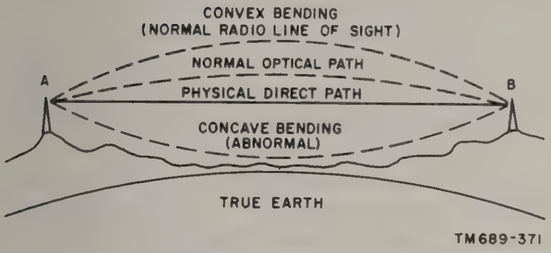


Figure 40. Beam bending.

d. Fading. When microwave signals arrive simultaneously at a receiving antenna through more than one path, fading might occur, because at certain times these signals will be out of phase and cancel each other. Fading may be caused by atmospheric factors, topographical factors, or a combination of both. Because fading is often due to a complex combination of atmospheric and topographic factors, it is difficult to predict the frequency and depth of fades that will occur over a given path. However, the following general rules provide some indication of the fading severeness that may be expected:

(1) Fading is more severe for paths over water than for paths over rough terrain.

(2) Paths over smooth surface, such as deserts, may cause severe fading. However, even a small amount of vegetation provides considerable protection.

(3) The severity of fading is worse in a tropical climate than in temperate zones.

(4) A well-mixed turbulent atmosphere is less likely to cause fading than a still one.

(5) Ground fogs are associated with bad reception conditions.

(6) Fading is worse during summer months than during winter months.

(7) Severe fading is most likely to occur during the early hours of the morning, 2300 to 0400, especially during the summer months.

(8) Deep fading is minimized by providing first Fresnel zone clearance.

(9) An excessive clearance, three times that necessary for first Fresnel zone clearance, is liable to increase the severity of fading, especially for paths over water.

(10) The severity of fading increases rapidly with the length of the hop. Therefore, use path lengths over 40 miles. Under temperate conditions, 30 miles is considered a good average and, under exceptionally unfavorable conditions, 25 miles is considered the limit.

e. Fade Nomograph.

(1) Figure 41 is a fade nomograph that gives some indication of the percentage of time that various depth fades occur during the summer. To determine the percentage of time that a fade of given depth occurs, draw a straight line between the point marked 30 miles and the depth of fade being checked. Extend the line until it reaches the *percent occurrence* scale, and read the number indicated.

(2) To determine the percentage of time that 20-db fades occur during summer nights, draw a line between the 30-mile point and No. 20 on the top *fade in db* scale. If this line is extended to the *percent occurrence* scale (fig. 41), the 20-db fades occur about .09 percent of the time or about 1 minute for every 24 hours of summer night operation.

(3) *The percent occurrence* of fades becomes smaller as the fade depth increases (fig. 41). Thus, 25-db fades, in summer nights, occur only about .03 percent of the time or 1 minute for every 72 hours.

(4) The fade nomograph (fig. 41) is based on the following conditions:

  (*a*) 30-mile paths.
  (*b*) Full Fresnel zone clearance.
  (*c*) Summer season.
  (*d*) Single hop system.
  (*e*) True earth profile.
  (*f*) The use of this nomograph for other

conditions is described in (5) through (8) below.

(5) The depth of fading is proportional to the path distance; it increases for longer path distances and decreases for shorter ones. The increase in fading depth for an extremely long path, if all the other conditions listed in (4) above are met, is about 10 db. To use the fading nomograph for such a path, add 10 to each number given in the *fade in db* scale. In an extremely long path (50 to 60 miles), 30-db fades occur about .09 percent of the time, and 35-db fades about .03 percent of the time, during summer nights.

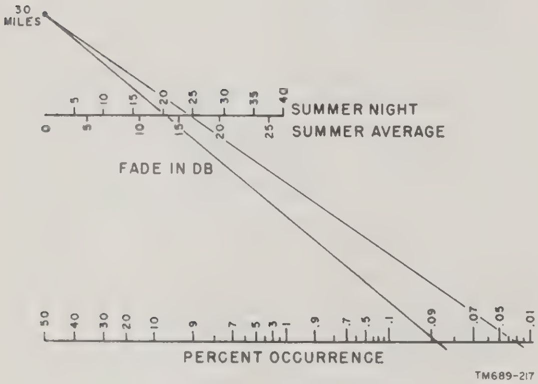


Figure 41. Fade nomograph.

(6) The depth of fading increases for paths that do not have full Fresnel zone clearance (or those having 2 or 3 times the required clearance). Thus, the fade increase is inversely proportional to the clearance (below full Fresnel zone). The maximum increase of a 10-db magnitude occurs for zero clearance (grazing path). The fading nomograph can be used for a grazing path by adding 10 to each number given in the *fade in db* scale.

(7) During the winter, fading occurs much less often. To use the fading nomograph, divide the number given in *fade in db* scale by two. Thus, during the winter nights, 10-db fades occur about .09 percent of the time, and 12.5-db fades, about .03 percent of the time.

(8) The fading nomograph indicates the percent occurrence of fades for a single hop. If there is more than one hop, a fade occurring somewhere along the system is increased by a factor equal to the number of hops. For example, if 20-db fades occur about .09 percent of the time in each hop of a 10-hop system, then a 20-db fade might occur somewhere along the line about .9 percent of the time.

(9) The procedures given in (1) through (8) above give only an approximation of the fading conditions that may exist over a path. These conditions can seldom be verified before installing the equipment. After installing the equipment, outages due to fading should be carefully logged. If fading is excessive, then alternate siting and diversity operation (par. 42) should be used.

41. Choosing Sites

a. Preliminary Mapping.

(1) *General.* When mapping a radio link, first get all available data on the area. Contour maps are desirable for this. The sources for these maps include Government agencies, such as Conservation, Forest Service, State, Country, Army, and Aeronautical, as well as the U.S. Geological Survey maps that show the topography of the area. Local maps and local power company information may be helpful in determining accessibility and possible commercial power.. When available, two types of topographic maps should be secured: one scaled at about 8 miles to the inch, covering the entire area involved (terminal to terminal); the other, scaled at ½ or 1 mile per inch, showing the detailed topography of each station-to-station path selected.

(2) *Principal and alternate routes, two-frequency system.*

(*a*) A preliminary route should be mapped, based on the information obtained from a contour map. In the following discussion, it is assumed that a two-frequency system is used (it is the preferred system).

(*b*) On the map, mark the terminal and drop-channel locations (if any). Circle all the high points, such as mountains, ridges, and tall buildings whose locations are known. By linking suitable high points, and with the trial-and-error procedure, select principal and alternate routes that meet the following requirements:

1. Station-to-station path distances do not exceed 30 miles.

2. Line of sight that exists between the stations of all paths. It is not necessary to make a detailed study of the path in this preliminary mapping stage. However, it is possible to judge paths that are either likely or unlikely to have clearance. For example, if the path goes on from one high point to another with no intervening obstacles, it is likely that an adequate line-of-sight clearance will be obtained. However, if there is a high mountain range between the two points at about the same elevation as these points, it is unlikely that line-of-sight clearance will be obtained.

3. A dog-leg route that minimizes internal signal interference (par. 39*b*(3)).

4. Avoiding overwater paths, desert paths, and paths over very flat terrains, if possible.

5. The number of hops kept to a minimum.

(3) *Example of preliminary route mapping.*

(*a*) Figure 42 illustrates the preliminary mapping of a radio relay system between the east and west terminals with a drop-channel point.

(*b*) Although a *straight line* path between the west terminal and the drop-channel is only about 30 miles, this path cannot be used because of the high intervening mountain ranges. Two mountain ranges exist along this straight line path. Therefore, two repeater points, one for each mountain range, are required if a *straight line* path is used. However, by choosing a path that goes through valleys, between mountain ranges, it is possible to cross this path with only one repeater. Two such *single-repeater* paths exist (fig. 42). On a preliminary observation basis, the path indicated by the solid line appears to have a better line-of-sight clearance; therefore, this path is chosen as the principal path.

(*c*) The terrain over the drop-channel point and the east terminal is relatively flat with few high points. By linking high points, two possible paths can be used. Both require the use of two repeaters. One (solid line) provides a dog-leg path in which $\emptyset_1$ and $\emptyset_2$ are over 10° (39*b*(3)) and provides path separations of about 30 miles each (fig. 43). The other path (dotted line), although shorter, has a $\emptyset_1$ equal to only 7°, and therefore is subject to internal link interference. Some shielding is provided by the mountainous terrain surrounding the drop-channel station. The solid line path is designated as the principal path.

b. Line-of-sight Considerations.

(1) *General.* After a specific path is chosen, it must be evaluated to determine whether it is suitable for transmission of radio signals. First determine whether a radio line of sight can be obtained between it and the next station (s). For a repeater station, a radio line of sight must be obtained in both east and west directions. The basic procedure outlined in (2) and (3) below can be used to check the line-of-sight paths between any two points.

(2) *Plotting profiles.*

(*a*) *General.* Profiles of the radio path may be plotted on either special profile or plain linear graph paper. The

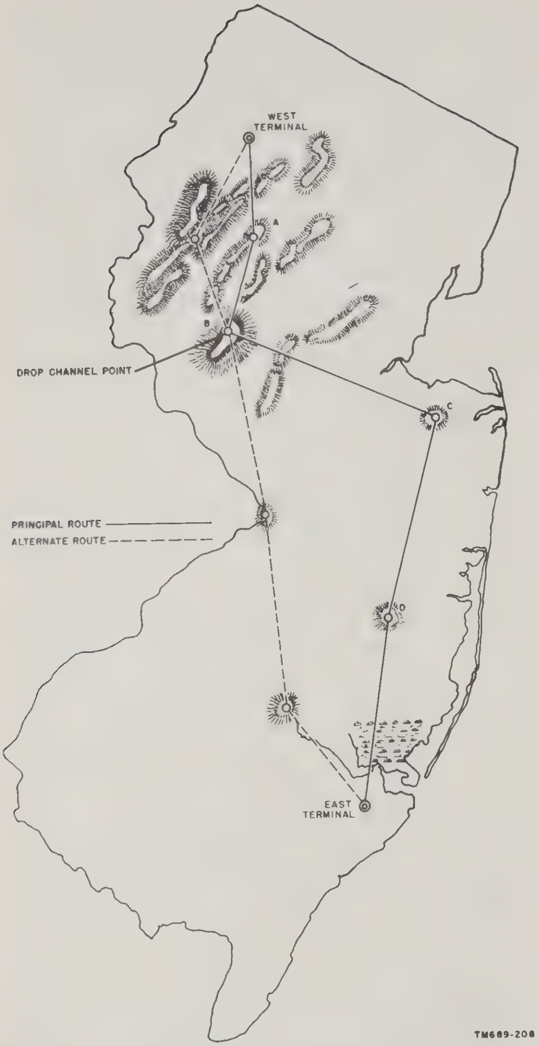

WEST TERMINAL
A
B
DROP CHANNEL POINT
C
PRINCIPAL ROUTE
ALTERNATE ROUTE
D
EAST TERMINAL
TM689-208

Figure 42. Preliminary mapping of radio relay system.

preferable and simpler method is to use the special profile paper. However, in some cases, such paper may not be available, and the profile may have to be plotted on linear graph paper. Both methods of plotting profiles are described in (*b*) and (*c*) below.

(*b*) *Plotting profiles on profile paper.* Figures 44 and 45 illustrate the contour map of a path and its profile, as plotted on profile paper. (Figure 46 plots the same path on linear graph paper.) The procedure used in plotting profiles on profile paper is as follows:

1. On a contour map, draw a straight line between the two stations being checked (A and B, fig. 44). Mark the elevations of the two stations, and designate one *0* miles and the other at a mileage equal to the separation between the two points. Follow the line from one point to the other, and mark the mileage (from *0* station) and elevation of each high

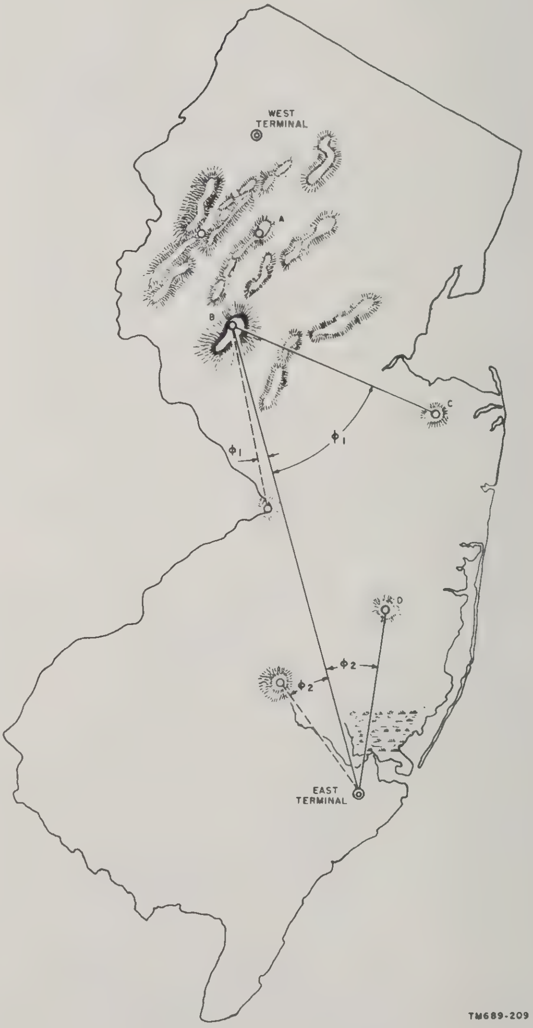

WEST TERMINAL
A
B
C
φ1
φ1
D
φ2
φ2
EAST TERMINAL
TM689-209

Figure 43. Dog-leg angles.

and low point in the intervening distance between the two points. Add to the geographical elevation given on the map, the height of trees, buildings, or any other obstacles that exist at the points involved. The elevation is estimated by noting the contour lines that appear on the map. A further explanation of the contour lines which appear on a map is given in FM 21–25.

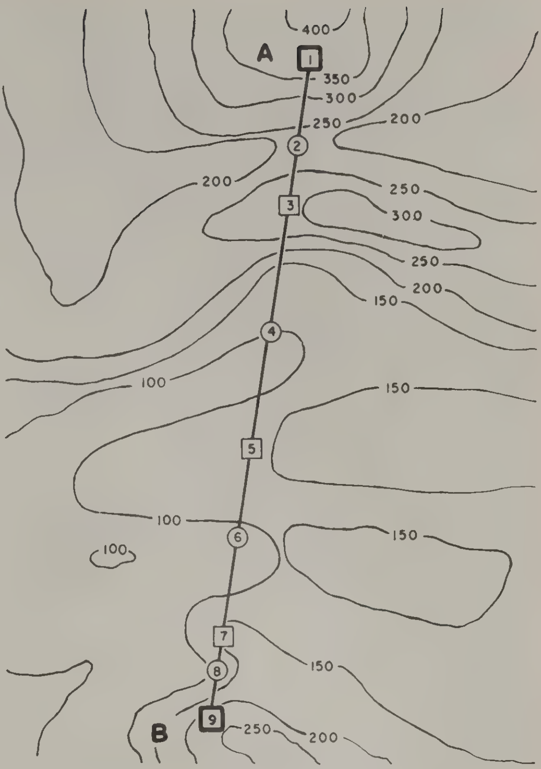
2. Choose the scales on the profile paper that are required for the path involved; plot the points marked on the map, onto the profile paper, and connect these points to form a curve (fig. 45).

(*c*) *Plotting profiles on linear graph paper.* The following procedure is used for plotting profiles on linear graph paper (fig. 46):

1. On the contour map, draw a straight line between the two points that are being checked. Locate and mark the elevation of the two stations, and of each high and low point along the line ((*b*) above).

2. Plot the contour points on linear graph paper. Choose a suitable scale along the horizontal axis that will provide for the entire path length. Along the vertical axis, use a scale that will take care of the highest elevation along the path.

3. Connect all contour points with a dashed line. The dashed curve does not give a true picture of the profile between the two points, because no correction has been made for the earth curvature. To make this correction, select a high or low point (R) which is as near as possible to the point halfway between the stations; then lower the height of all prominent points in both directions from R, by an amount equal to that given in the monograph (fig. 47). Connect all of these points by a solid line. This curve can be used to check the line-of-sight path.



LOCATION	MILEAGE	ELEVATION	TREES	TOTAL ELEVATION
1	0	380	20	400
2	3	240		240
3	6	280		280
4	11	100		100
5	16	135	25	160
6	20	60		60
7	24	160		160
8	26	140		140
9	28	220		220

TM689-210

Figure 44. Contour map of path.

(3) *Checking path clearance.*

(*a*) *General.* Since a profile of the path is available, it must be studied to determine the following points:

1. If the path (including tower heights) is clear of all obstructions. If it is not, another site must be selected, and new profiles

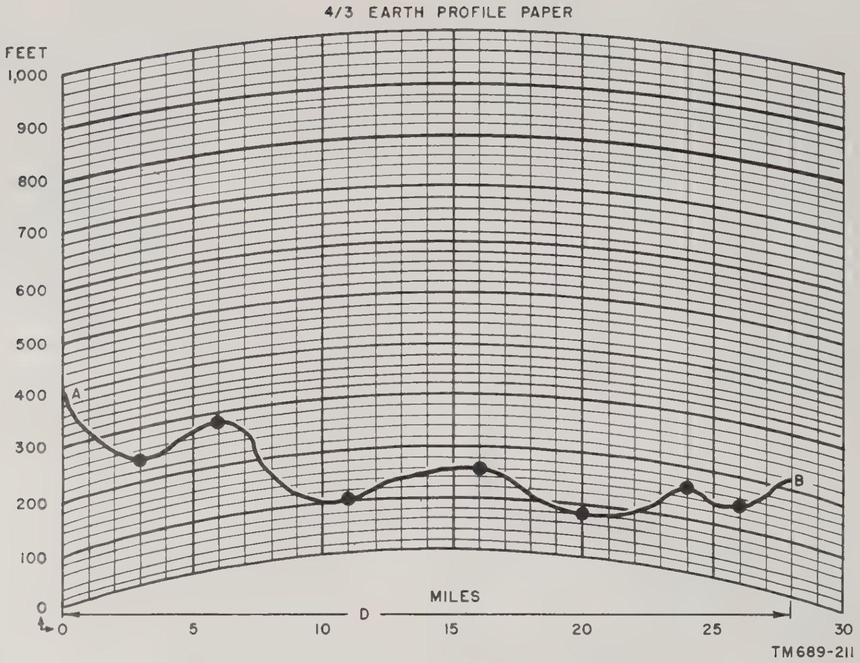


Figure 45. Profile plotted on profile paper.

made up until such a path is obtained. Shorter path lengths may have to be used.

2. If the path is clear, determine the number of feet above high contours. Obtain first the Fresnel zone clearance (par. 40*c*(2)).

(*b*) *Procedure for checking path clearance.* The procedure for checking path clearance is given in *1* and *2* below. This procedure is illustrated in figure 46.

1. On the profile diagram, draw a straight dashed line between the

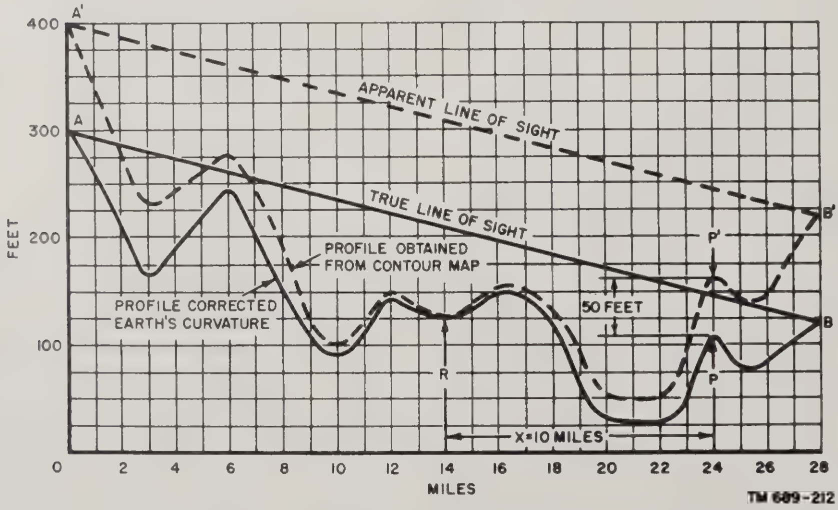


Figure 46. Profile plotted on linear graph paper.

two stations. Note the points on the profile that provide either the smallest clearance or intersect the dashed line. In figure 48, these points are 6, 16, and 24 miles from station A.

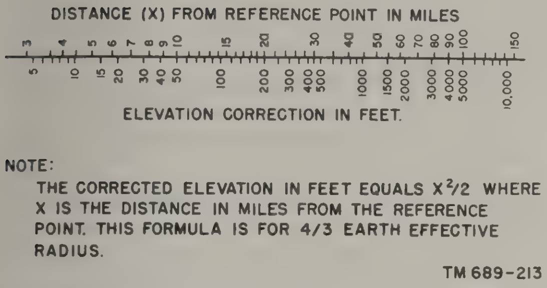

DISTANCE (X) FROM REFERENCE POINT IN MILES
3
4
5
6
7
8
9
10
15
20
30
40
50
60
70
80
90
100
150
5
10
15
20
30
40
50
100
200
300
400
500
1000
1500
2000
3000
4000
5000
10,000
ELEVATION CORRECTION IN FEET.
NOTE:
THE CORRECTED ELEVATION IN FEET EQUALS X²/2 WHERE X IS THE DISTANCE IN MILES FROM THE REFERENCE POINT. THIS FORMULA IS FOR 4/3 EARTH EFFECTIVE RADIUS.
TM 689-213

Figure 47. Linear graph paper profile correction nomograph.

2. To each of these high points, add a heavy line that is equal in elevation to the first Fresnel zone clearance that is required. In the example (fig. 48), the Fresnel zone clearances that are required are:

$$F_r \text{ at 6 miles} = 51\sqrt{\frac{6 \times 22}{28}} = 112 \text{ feet}$$

$$F_r \text{ at 16 miles} = 51\sqrt{\frac{16 \times 12}{28}} = 135 \text{ feet}$$

$$F_r \text{ at 24 miles} = 51\sqrt{\frac{24 \times 4}{28}} = 92 \text{ feet}$$

3. If the dashed line that is drawn (*1* above) does not clear all obstacles plus the Fresnel zone clearance line, then the *tower height above trees* that is required to provide such clearance, must be determined. In some paths this is done by increasing the elevation height of the two stations (on the profile map) in steps of 50 feet until adequate clearance is obtained. When adequate clearance is obtained, note the angle between the path and ground at each station. The tower height above trees that is required to provide

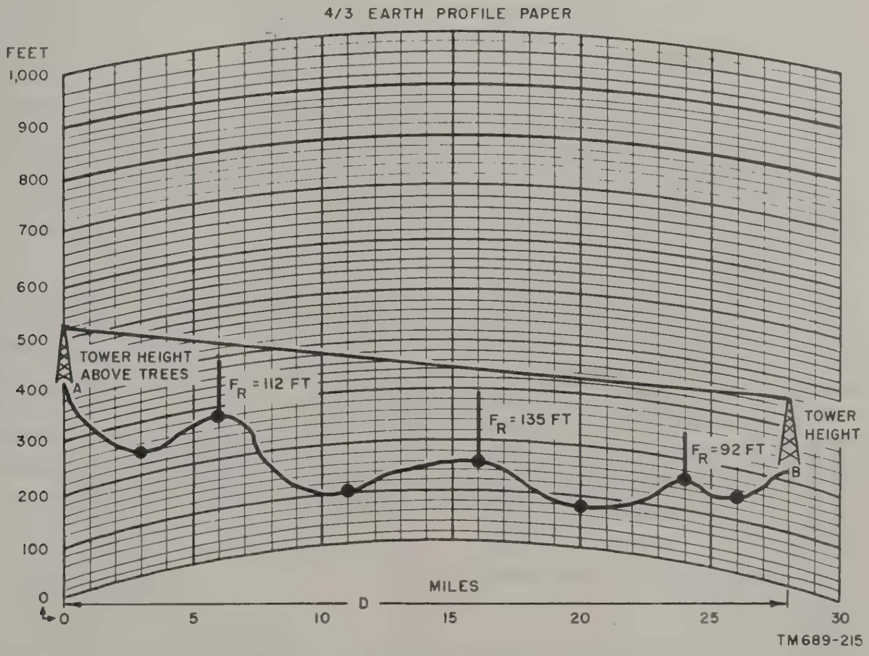

4/3 EARTH PROFILE PAPER
FEET
1,000
900
800
700
600
500
400
300
200
100
0
TOWER HEIGHT ABOVE TREES
A
F_R = 112 FT
F_R = 135 FT
F_R = 92 FT
TOWER HEIGHT
B
MILES
D
0
5
10
15
20
25
30
TM689-215

Figure 48. Profile diagram showing clearance requirements.

this clearance at all points, is 130 feet at station A, and 150 feet at station B (fig. 48).

4. However, this procedure may have to be varied to conform to the individual conditions that exist for the path being checked. For example, at a repeater station, the same tower is used for two paths, and the tower height that is selected must be advantageous to both paths. However, where strong reflected signals are expected, it may be desirable to make one tower as low as possible and the other as high as possible.

Note. In plotting the profile, the elevation figures used were actual geographic elevation, plus the height of trees or other obstacles. For example, at station A, figure 48, the actual geographic elevation is 380 feet, but because there are 20-foot trees at the location, the elevation plotted is 400 feet. Therefore, a minimum tower height (20 feet at station A) equal to the height of the surrounding obstacles has already been assumed in making up the profile diagram. Any additional height that is required to provide sufficient path clearance is, therefore, designated as *tower height above trees.* The actual tower that is required at station A is 130 feet for tower height above trees, plus 20 feet to reach the top of the trees.

5. The maximum tower height of Tower AB–216/U, which is obtained with Radio Set AN/TRC–29, is 200 feet. Therefore, the total tower height (the tower height above trees plus the height of the trees) should not exceed 200 feet. If CAA regulations limit tower heights to 150 feet, then the maximum tower height that can be used is 150 feet. Where preliminary calculations show that a tower height greater than 200 feet is required, the use of a 200-foot tower should be considered. Calculate the clearances with this tower.

6. After the tower heights are determined, calculate the tilt angles of the antenna with the table below. As indicated in this table, the difference in elevation between the two sites is divided by the separation in miles. With this ratio, the tilt angle in degrees can be determined by using the nearest number in the table. The difference between station A and B is 530 minus 370, or 160 feet (fig. 48). The separation is 28 miles, so the ratio is about 5.7. Because this is well below 46, the tilt angle is 0°. If one elevation were 1,100 feet, the other 2,900 feet, and the separation were 10 miles, the ratio would be 180, which is about halfway between 138 and 230. Therefore, the tilt angle for the 1,100-foot elevation would be —2°, and for the 2,900-foot elevation, would be +2°. The table below shows the antenna tilt angle.

Elevation difference in feet separation in miles	Tilt angles in degrees	Elevation difference in feet separation in miles	Tilt angles in degrees
46	0.5	508	5.5
138	1.5	600	6.5
230	2.5	694	7.5
323	3.5	788	8.5
415	4.5	883	9.5

c. Reconnaissance.

(1) At this point, the location of each repeater has been tentatively selected, based on the information on the available maps. Inspect the areas involved, and check the sites selected to be sure that they meet the requirements of the radio relay system ((2) below).

(2) A survey of both the principal and alternate routes should be made. Be sure to check the accuracy of the maps that are used (especially at the high points). Add to these maps such information as the location and height of tall buildings, location and height of timber land, power lines, and smaller

roads which may not appear on the map.

(3) The principal factors that determine the suitability of a site are proper radio line of sight (checked previously by profile diagrams), good roads, and availability of power lines. Mountain top sites should be selected when the profile diagrams indicate that maximum elevation is required. However, if the profile diagrams indicate that adequate clearance can be obtained, use lower lever sites where there are better roads and accessible power.

(4) Generally, radar sites are satisfactory for radio relay sites, if a reasonable distance is maintained between radar and communication equipment. However, be sure that radio and radar frequencies are not harmonically related.

(5) Note the terrain of the path, and record on the map any flat terrain, especially if it does not have vegetation. Avoid these paths and paths over water; they may cause strong reflected signals.

(6) After completing the survey, review the material contained in paragraphs 40 through 44. Re-evaluate all paths on the basis of this material and the additional information that is obtained during the reconnaissance. Investigate new paths or routes until a satisfactory system is mapped out.

42. Diversity Operation

a. General. Fading might occur on a path with multipath signals because these signals may reach the antenna out of phase and thus cancel each other. To overcome fading, use two receiving antennas located so that when cancellation is *likely* to occur at one antenna, it is *unlikely* to occur at the other. An adequate signal exists at one or the other of these antennas at all times. Radio Set AN/TRC–29 automatically selects the best signal when it is connected for diversity operation.

b. Diversity Spacing.

(1) Space diversity uses two receiving antennas which are spaced vertically to give reflected wave paths of different length. These paths differ in length by ½ wavelength. Figure 49 is a nomograph that can be used to determine the vertical spacing in feet that is required to have one antenna at a signal maximum when the other is at signal minimum. Refer to figure 51 to determine the effective antenna height.

(2) To use the nomograph, proceed as follows:

(*a*) Draw a straight line from the appropriate point on the *path distance* scale to the appropriate point on the *effective transmitting height* scale, and extend this line until it intersects the horizontal line. In the example in figure 49, the path length is 30 miles, and the effective transmitter height is 100 feet.

(*b*) Draw another line between the point of intersection ((*a*) above) and the appropriate point on the *frequency* scale. In the example given in figure 49, the transmitter frequency is 2,000 mc.

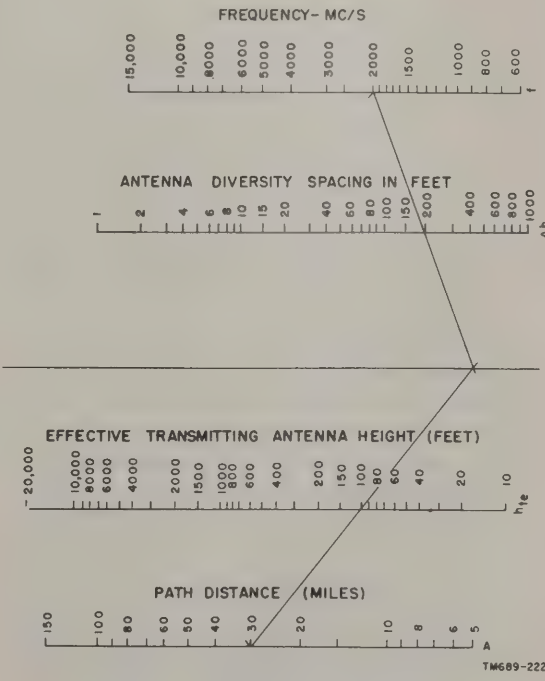

FREQUENCY- MC/S
15,000
10,000
8000
6000
5000
4000
3000
2000
1500
1000
800
600
f
ANTENNA DIVERSITY SPACING IN FEET
1
2
4
6
8
10
15
20
40
60
80
100
150
200
400
600
800
1000
Δh
EFFECTIVE TRANSMITTING ANTENNA HEIGHT (FEET)
20,000
10,000
8000
6000
4000
2000
1500
1000
800
600
400
200
150
100
80
60
40
20
10
h_{te}
PATH DISTANCE (MILES)
150
100
80
60
50
40
30
20
10
8
6
5
A
TM689-222

Figure 49. Space diversity nomograph.

(c) Read the required antenna spacing at the point that the line ((b) above) intersects the *antenna diversity spacing* scale. In figure 49, the spacing required is 200 feet.

(3) If the indicated spacing is too large for the available sites and towers, use a spacing as large as practical. Only a small improvement results from vertical spacing of more than 50 feet. Therefore, in the example in figure 49, a 50-foot spacing should be used. If the indicated spacing is too small, multiply the indicated spacing by 3 or 5, and use the new spacing. The diversity antenna may be located above or below the primary antenna. However, when located below this antenna, it should clear the surrounding trees and provide the proper line-of-sight path clearance.

(4) The nomograph (fig. 49) is based on the following formula:

$$\text{Spacing in feet} = \frac{1.3 \times 10^6 \times d}{F \times h_{te}}$$

Where d is the separation of the two stations in miles,
F is the frequency of operation in mc, and
h_{te} is the effective height of transmitting antenna above the reflecting plane, tangent to the earth at the point of reflection.

The procedure to determine the reflection point and effective antenna height for paths that cross smooth terrain is given in *c* below.

c. Determining Reflection Point and Effective Antenna Height. In any path over smooth terrain which may cause strong reflection signals, the effective height of the antennas as plotted on a profile map is less than the actual height of the antenna. Use this effective height when calculating diversity spacing. To determine the effective height of the antenna, find the reflection point of the path. The reflection point and effective height are found as follows:

(1) Over a smooth terrain (fig. 50), the reflection point can be approximately determined by selecting d_1 and d_2 (defined below) so that the following equation will be satisfied:

$$\frac{H_t}{H_r} = \frac{d_1}{d_2}$$

Where H_t is the height of the transmitting antenna,
H_r is the height of the receiving antenna,
d_1 is the distance from the transmitting antenna to the reflection point,
d_2 is the distance from receiving antenna to reflection point.

(2) From the equation ((1) above), determine the approximate location of the reflection point, and draw a line tangent to the earth at this point (fig. 50).

(3) Estimate the distance (d_1) from the transmitter to the point that is tangent to the reflecting plane. Note that d_1 will be greater than one-half the total distance (d) when the transmitter height (h_t) is greater than the receiver height (h_r) and vice versa.

(4) The effective height graph in figure 51 (A, B, C, and D) can be used to verify that the proper location of the reflection point has been selected, and to determine the effective antenna heights.

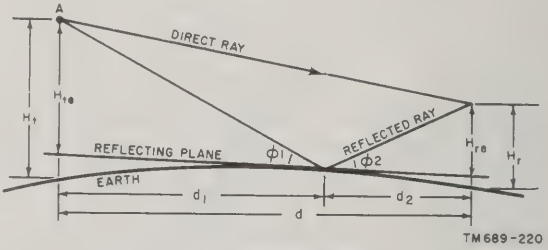


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Figure 50. Reflection point chart.

(5) Plot a point A at the intersection of h_t (600 feet in the example given in figure 51) and the estimated distance d_1 (25 miles). Similarly, plot a point B for the receiver height (250 feet) and distance d_2 (5 miles).

(6) Note whether points A and B lie on the same oblique line. If they do not

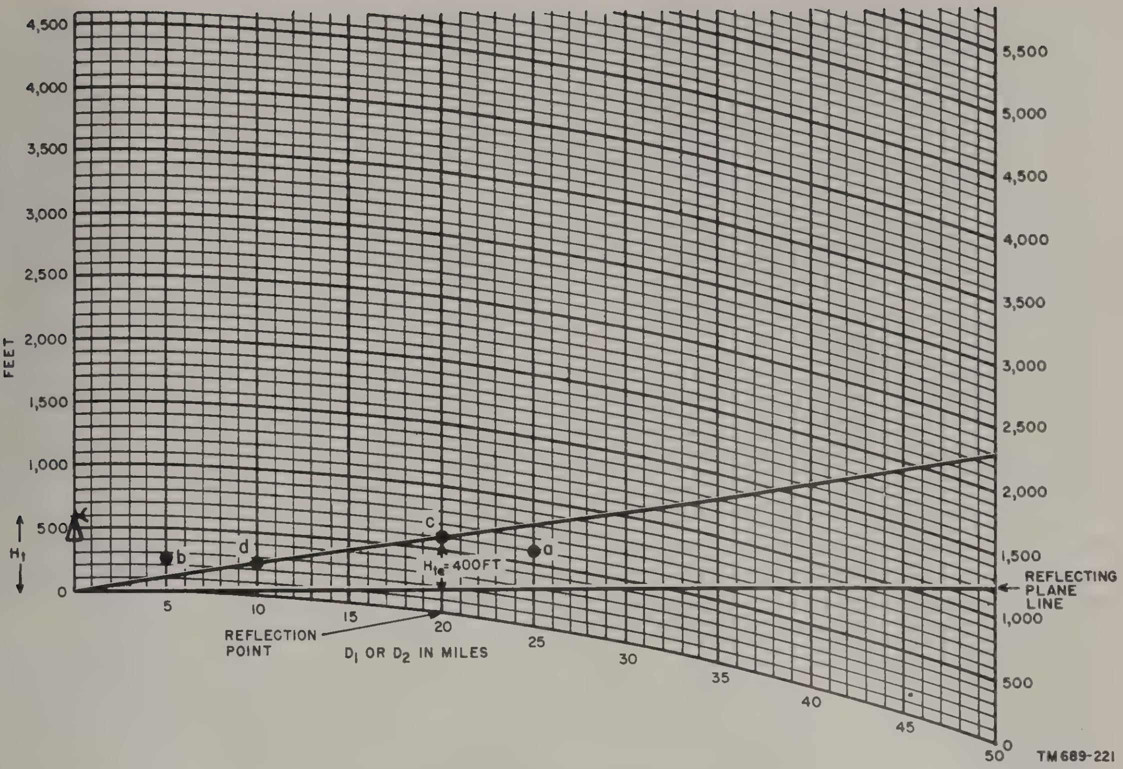

Figure 51. Effective height graph.

(fig. 51), the proper reflection point distance has not been chosen.

(7) Assume a new value of distance d_1 (20 miles) and plot new points C and D. Now the two points lie on the same oblique plane, and the proper reflection point has been chosen.

(8) The effective transmitter height (h'_t) is the height in feet of point C (h_t, d_1) above the reflecting plane (400 feet). Similarly, the effective height of the receiver (h'_r) is the height of point D (h_r, d_2), above the reflecting plane (200 feet).

(9) When using paths over an elevated smooth valley floor, the elevation of this floor is first subtracted from the actual values of h_t and h_r. Over irregular terrain which may have a smooth area at the point of reflection, the reflection point must first be estimated on a true smooth earth basis. The elevation of the flat earth at this point is then used (as in the case of the valley floor) in determining the effective antenna heights.

43. Calculation of Theoretical System Signal-to-Noise Ratio

a. General.

(1) With the radio relay system tentatively mapped out, the theoretical system signal-to-noise ratio can be calculated. It serves two purposes:

(*a*) The performance of the radio relay system can be more accurately predicted when the theoretical system signal-to-noise ratio is known. For example, the system signal-to-noise ratio must be known to evaluate the effects of fading on the communication service (*f* below).

(*b*) An excellent indication of the fact that the radio relay system has been planned, installed, adjusted, and tuned properly is obtained when the measured signal-to-noise ratio is at least equal to, or not much less than, the calculated signal-to-noise ratio.

(2) Two values of signal-to-noise ratio are: the video signal-to-noise ratio that is obtained over the rf portion of the radio relay system, and the audio signal-to-noise ratio that is obtained in a ppm radio relay system.

b. Path Attenuation. To use the signal-to-noise curves given in *c* and *d* below, it is necessary to know the path attenuation (par. 40*b*(2)) of the hop. The direct path attenuation can be determined from figure 34.

c. Video Signal-to-noise Ratio, Single Hop. The video signal-to-noise ratio versus path attenuation for a single-hop system that uses the full 4.5-mc bandwidth is plotted in figure 52. A signal-to-noise ratio of 38 db is obtained for a path attenuation of 84.5 db (30-mile 200-foot transmission line path). A decrease in path attenuation below 70 db does not greatly improve the signal-to-noise ratio; path attenuations over 110 db make the hop practically unusuable for communication service. The video signal-to-noise ratio is better in a ppm radio relay system because the bandwidth is limited to 1 mc. This is illustrated in figure 53, which plots the video signal-to-noise ratio versus path attenuation for a ppm system in which the bandwidth of the receiver video output is limited by a 1-mc low-pass filter. A signal-to-noise ratio of 47 db is obtained when the path attenuation is 84.5 db.

d. Audio Signal-to-Noise Ratio in Single-Hop Ppm Radio Relay System. The audio signal-to-noise ratio versus path attenuation, for a single-hop ppm radio relay system, is plotted in figure 54. An improvement in signal-to-noise ratio is obtained over the video signal. For example, a 58.5-db signal-to-noise ratio is obtained for a path attenuation of 84.5 db. This improvement in signal-to-noise ratio is due to the use of a 1-mc video bandwidth and pulse position modulation in the AN/TCC–13 equipment. Communications fail when path attenuation exceeds approximately 113 db or the signal-to-noise ratio falls below 25 db.

e. Signal-to-noise Ratio in Multihop System.

(1) In a multihop system, each hop adds noise to the signal, so that the signal-to-noise ratio decreases as the number of hops increases. The chart below indicates the decrease in signal-to-noise ratio obtained for 2 to 20 uniform hops.

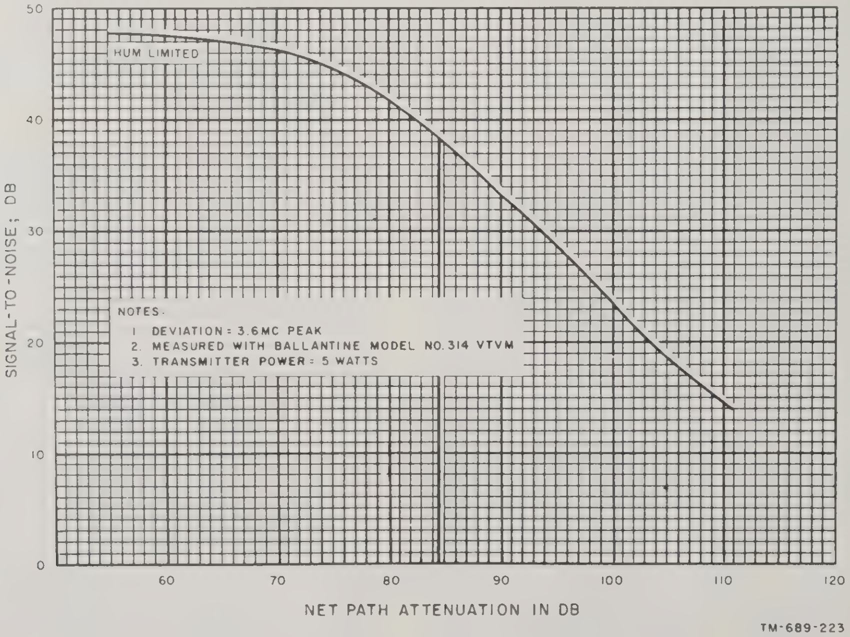

Figure 52. Video signal-to-noise graph, 4.5-mc bandwidth.

Number of hops	Signal-to-noise decrease in d-b	Number of hops	Signal-to-noise decrease in d-b
2	3	11	10.4
3	4.8	12	10.8
4	6	13	11.2
5	7	14	11.4
6	7.8	15	11.7
7	8.4	16	12.0
8	9.0	17	12.3
9	9.5	18	12.5
10	10.0	20	13.0

(2) In systems that use 30-mile hops (where the video signal-to-noise ratio for a single hop is 47 db), the video signal-to-noise ratio drops to 44 db for two hops, 37 db for 10 hops, and 34 db for 20 hops. Similarly, the audio signal-to-noise ratio in a ppm system drops to 55.5 db for 2 hops, 48.5 db for 10 hops, and 45.5 db for 20 hops.

(3) In most installations, the hops are not uniform. However, except when an extremely short or long path is involved, a good approximation of the signal-to-noise ratio (within 3 db) can usually be obtained by assuming that they are all 30-mile hops. This is particularly true for systems that use more than 5 hops.

f. Effect of Fading.

(1) General. After the theoretical system signal-to-noise ratio is calculated, estimate the outage time (outage time is the time when communication service is interrupted) because of fading. The procedures for determining this outage time in single and multihop systems is indicated in (2) and (3) below.

(2) *Single-hop system.* The path attenuation figures given in *b* above are for the direct signal path. Fading increases the effective path attenuation by an amount equal to the depth of the fade. For example, during a 20-db fade, the path attenuation for a normal 86-db path would be 106 db. The video signal-to-noise ratio during this fade is 17.5 db, and the audio signal-to-noise ratio 35 db (figs. 52 and 54). This signal-to-noise ratio is adequate

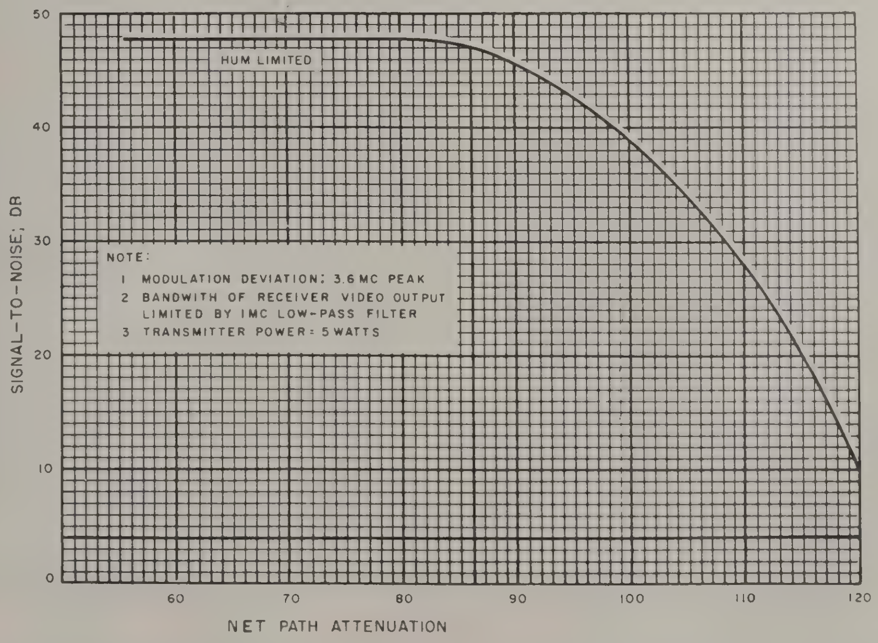

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Figure 53. Video signal-to-noise ratio graph, 1-mc bandwidth.

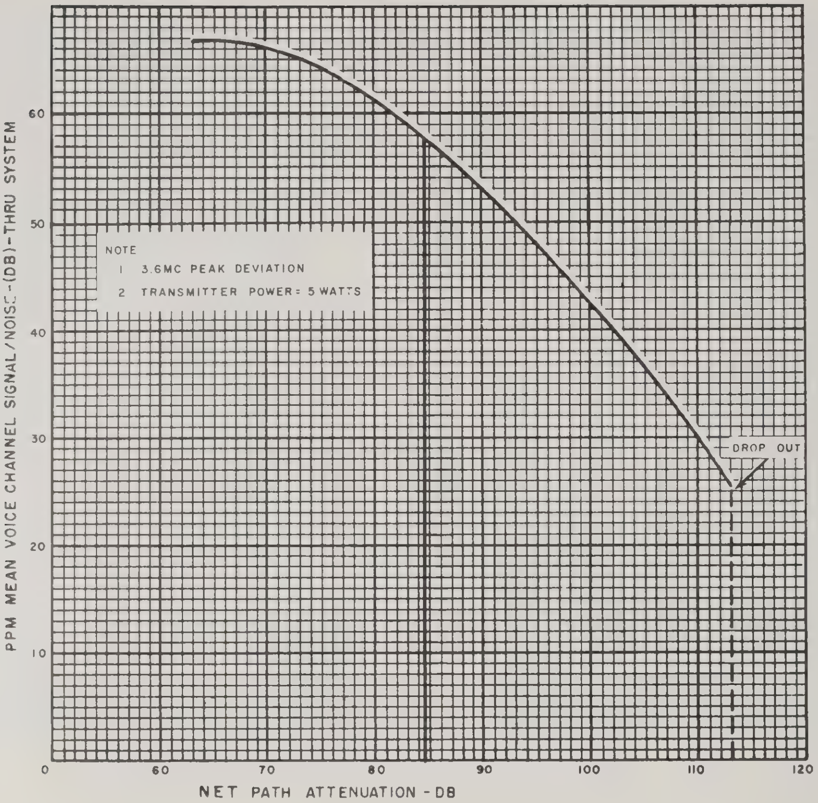

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Figure 54. Audio signal-to-noise ratio graph for ppm radio relay system.

to maintain communication service. Therefore, 20-db fades do not interrupt service over this path. However, 25-db fades reduce the signal-to-noise ratio practically to the point of service failure. It can be estimated that communication service will be interrupted for fades above 25 db. Under the worst possible atmospheric conditions (summer nights), fades of this depth occur only about .03 percent of the time, or 1 minute out of every 72 hours of operation (for a 30-mile path with full Fresnel zone clearance) (fig. 41). If this path is grazing or extremely long so that the depth of fades are increased by 10 db (par. 40*e*), the outage time, because of fading, would be about .8 percent during summer nights.

(3) *Multihop systems.*

(*a*) As in single-hop systems, the system signal-to-noise ratio is decreased during fading. The procedure for determining the signal-to-noise ratio during fades of a system containing more than one hop is as follows:

1. Determine the signal-to-ratio over hops (*e* above).

2. Determine the signal-to-noise ratio over a single hop for the fade conditions being investigated.

3. Determine the difference between the values obtained in *1* and *2* above.

4. With the chart below, determine the subtraction number.

Difference (in db)	Subtraction number (in db)	Difference (in db)	Subtraction number (in db)
0.0	3.0	4.0	1.4
0.5	2.8	5.0	1.2
1.0	2.5	6.0	1.0
1.5	2.3	8.0	.6
2.0	2.1	10.0	.4
2.5	1.9	15.0	.1
3.0	1.8	20.0	.04

5. Subtract the subtraction number that is determined in *4* above from the lower of the two values that are determined in *1* and *2* above. The result is the system signal-to-noise ratio.

(*b*) The system signal-to-noise ratio of a 10-hop ppm system (with normal path attenuations of 84.5 db) during a 20-db fade is as follows:

1. The audio signal-to-noise ratio of 9 hops in this system is 49 db.

2. The audio signal-to-noise ratio in a single hop with a 20-db fade is 38 db.

3. The difference between the values obtained in *1* and *2* above is 11 db.

4. This difference provides a subtraction number of about .4 (*f*(3) (*a*)*4* above).

5. The system signal-to-noise ratio during such a fade is, therefore, 38 minus .4, or 37.6.

(*c*) To estimate the outage time because of fading, proceed as follows:

1. Determine the fade depth that causes a communication service to be interrupted. In a ppm radio relay system, the system signal-to-noise ratio that is obtained during deep fades is practically the same for a single hop as it is for a number of hops ((*b*) above). The fade depth that interrupts communication is the same for multi-hop systems as it is for single-hop systems above 25 db.

2. With the procedure in paragraph 40*e*, estimate the percentage of time that fade depth occurs (*1* above).

44. Final Route Mapping and Marking

a. General.

(1) It was recommended in previous paragraphs that paths be limited to 30 miles, but it was stated that the number of hops used should be kept to a minimum. Assume that two routes are available to cross a 70-mile separation between a drop-channel station and a terminal. One route uses three hops, all under 30 miles. The other uses two hops, but one is 35 miles and the other 37 miles.

(2) It was recommended previously that full Fresnel zone clearance be obtained. It was also stated that readily accessible lower level sites are preferred to mountain tops. In some installations, the mountain top provides full Fresnel zone clearance, but the lower level site provides only half of the recommended clearance.

(3) When a conflict of this type arises, the effect on the performance of the system in terms of signal-to-noise ratio and outage time because of fading should be considered (par. 40*e*).

(4) Assume that a permanent, multihop, backbone communication system is being planned which will be used continuously and often to its fullest capacity. Choose the three-hop route and mountain-top site because the highest degree of reliability is desired.

(5) The final route and sites should be chosen and marked on the map showing tower heights to be used, antenna azimuth, and tilt angle, as determined from map and profile diagram.

b. Use of Video Reshaper and Drop-Channel Equipment in Ppm Radio Relay System.

(1) Pulse Form Restorer Group AN/TRA–10 and Multiplexer Group AN/TCA–1 are used in a ppm radio relay system to provide drop-channel and video-reshaper facilities at repeater stations. If two drop channels are required at a repeater point, Pulse Form Restorer Group AN/TRA–10

is used. When more than two and up to eight drop channels are required, Multiplexer Group AN/TCA–1 is used. The drop-channel points in the radio relay system should be designated *TRA-10* or *TCA-1* (fig. 55).

(2) The video signal in a ppm radio relay system should be reshaped after it has been relayed over five repeater stations. The video signal is automatically shaped at every drop-channel station. However, in some installations, drop-channel facilities may not be required at every sixth station, and Pulse Form Restorer Group AN/TRA–10 equipment is inserted at the sixth repeater to reshape the video signal. This also makes drop-channel facilities available at this station.

(3) Assume that a 10-hop system is required with a drop-channel at the second east-west repeater station. In this system, a signal going from east to west goes through seven repeater stations between the drop-channel station and the west terminal. Consequently, a pulse restorer must be located at either the fourth, fifth, sixth, seventh, or eighth east-west repeater station. (A pulse restorer at any one of these stations satisfies the requirement of reshaping at least every sixth station.) If it does not matter which station is used for this purpose, the pulse restorer equipment should be located at the sixth repeater, because it is midway between the second repeater and west terminal. The station chosen should be designated *TRA-10* on the map.

c. Use of Cross Polarization. With coaxial rf feed lines, the possibility of internal link interference can be minimized by cross polarization. That is, using horizontal polarization for the first two hops, vertical for the second two hops, horizontal for the third two hops, and so on. The change from vertical polarization to horizontal polarization should be at a receiving station that is receiving f_1 or f_2 as the case may be; that is, not at the transmitting repeater. On the map (fig. 55), designate antennas for first hop by *H*, the second hop by *H*, third hop by *V*, and so on.

Note. When using Radio Frequency Transmission Line Assembly CG–1013/U, all stations should use horizontal polarization. If this is not done, the horizontal path receiver may lock on the vertical path receiver regardless of signal.

Section II. INSTALLATION OF RADIO SET AN/TRC–29

45. Introduction

a. This section describes the procedure for installing Radio Set AN/TRC–29 at terminal and repeater stations. It does not cover procedures for interconnecting the equipment. These procedures are covered in paragraphs 55 through 64.

Note. The transmitter and receiver racks of Radio Set AN/TRC–29 must be installed in a shelter. Refer to paragraph 138 for type of shelters that can be used.

b. This equipment is installed in three stages:

(1) A station layout is made for each station (par. 46).

(2) Equipment is uncrated, unpacked, positioned, and checked (par. 47).

(3) Equipment is installed (pars. 48–51).

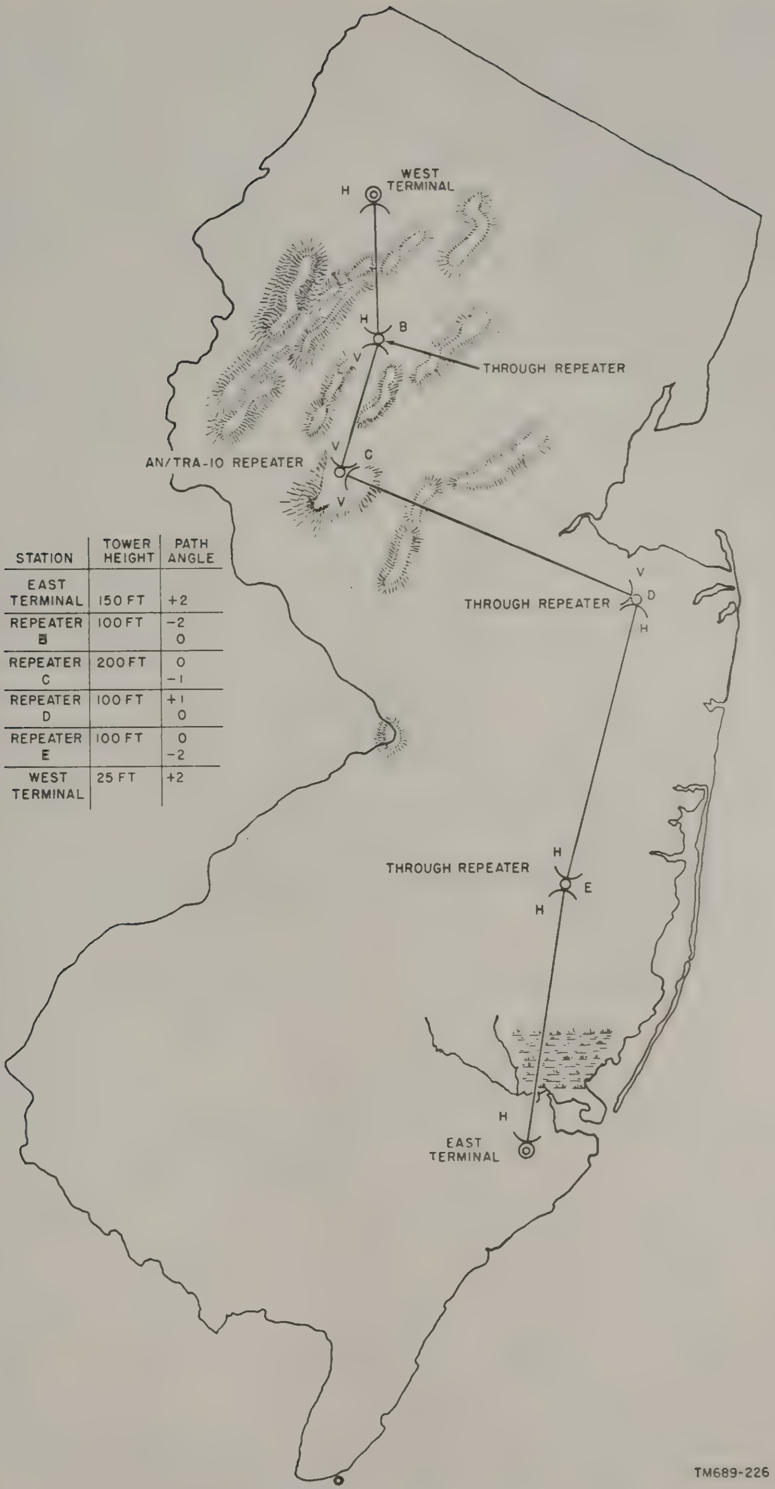
46. Station Layouts

a. General. Before any equipment is unpacked, plan the station layout and make a diagram showing the location of all major components; a major component can be placed properly as it is unpacked. The basic layout requirements for each type station are described in *b* through *f* below.

Note. Normally, a spare radio set is installed at each station. In this and other chapters in this manual, this set is referred to as the *spare set;* the other radio sets are identified as the *operating sets.* Individual components of the operating sets are identified by the direction of signal transmission, such as east-west receiver or west-east transmitter. These designations are placed on the station layout.

b. Terminal Stations. A proposed terminal station layout is shown in figure 56. This layout can be modified to meet individual station requirements if the instructions below are observed:

(1) Locate the tower near the shelter. The wider side should face the next station


H
WEST TERMINAL
H
B
THROUGH REPEATER
V
V
AN/TRA-IO REPEATER
C
V
V
D
THROUGH REPEATER
H
H
THROUGH REPEATER
E
H
H
EAST TERMINAL
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STATION	TOWER HEIGHT	PATH ANGLE
EAST TERMINAL	150 FT	+2
REPEATER B	100 FT	−2 0
REPEATER C	200 FT	0 −1
REPEATER D	100 FT	+1 0
REPEATER E	100 FT	0 −2
WEST TERMINAL	25 FT	+2

Figure 55. Final route map.

(direction of transmission). It should be possible to connect the 25-foot deicing cable between the tower and the ground launcher.

(2) Locate the ground launcher of the surface-wave transmission line close to the receiver racks. It should be possible to connect the 15-foot rf cable (connected at one end to the ground launcher) to either receiver rack. The ground launcher can be mounted on the roof or to the wall of the shelter.

(3) The transmitter and receiver racks of each radio set should touch the receiver rack on the left (looking from the front).

(4) Although the radio sets should be close together, there must be space to move freely between them.

(5) Maximum separation between the video equipment and the operating radio set is 8 feet if video cables provided are used. If possible, this separation should be about 6 feet as indicated in figure 56.

(6) Allow for cable troughs between all equipment (fig. 56). Note that cable troughs extend underneath the equipment and terminate at the rear side so

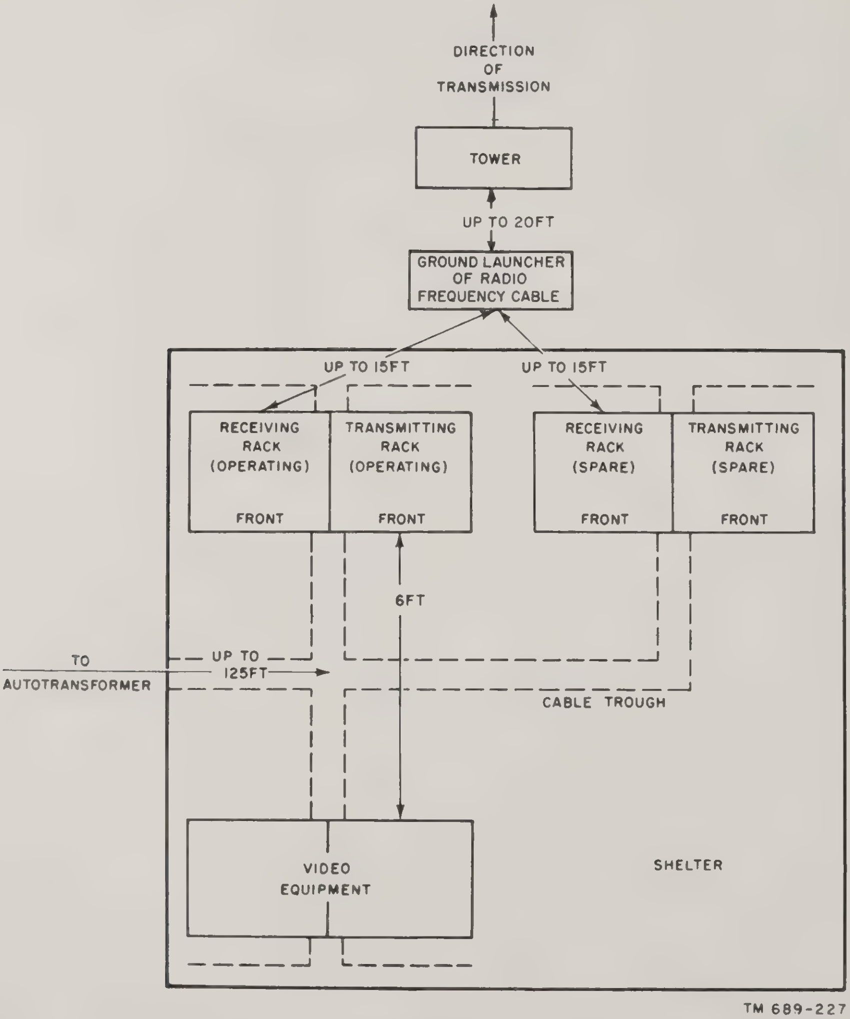

DIRECTION OF TRANSMISSION
TOWER
UP TO 20FT
GROUND LAUNCHER OF RADIO FREQUENCY CABLE
UP TO 15FT
UP TO 15FT
RECEIVING RACK (OPERATING)
FRONT
TRANSMITTING RACK (OPERATING)
FRONT
RECEIVING RACK (SPARE)
FRONT
TRANSMITTING RACK (SPARE)
FRONT
6FT
TO AUTOTRANSFORMER
UP TO 125FT
CABLE TROUGH
VIDEO EQUIPMENT
SHELTER
TM 689-227

Figure 56. Proposed terminal station layout.

that connection can be made to jacks located at the back of the equipment.

(7) Radio equipment should be located within 150 feet of the primary power source.

c. Through Repeater Stations. Figure 57 shows a proposed through repeater station layout. This layout can be modified to meet individual station requirements if the following instructions are observed:

(1) The tower should be located within 25 feet of the shelter. In addition, it should be possible to install the tower so that wider sides face, approximately, the directions of transmission.

(2) The ground launchers for both antennas should be as close to their associated receiver racks and *spare* receiver rack as possible. It should be possible to connect the 15-foot rf cable (connected at one end to the ground launcher) to either its associated receiver rack or the spare receiver rack.

(3) The transmitter and receiver racks of each radio set should touch the receiver rack on the left (looking from the front).

(4) The radio sets should be close together, but there must be space to move freely between them. Generally, a 1.5-foot separation between operating and spare sets, and a 6-foot separation between operating sets meet this requirement.

(5) Allow for cable troughs between all equipment (fig. 57). Note that cable troughs extend underneath the equipment and terminate at the rear side so that connection can be made to jacks at the back of the equipment.

(6) Radio equipment should be located within 150 feet of the primary power source.

d. Drop-Channel Repeater Station. Figure 58 shows a proposed drop-channel station layout. This layout is exactly the same as that for a through repeater station except for the addition of the drop-channel equipment. This layout can be modified to meet the individual requirements of the station if the following instructions are observed:

(1) Follow the instructions in *c*(1) through (6) above.

(2) Position the drop-channel equipment so that there is a maximum separation of 8 feet between it and all radio sets. If possible, this separation should be about 6 feet (fig. 58).

e. Station Layout for Diversity Operation.

(1) *Terminal.* The station layout for diversity operation at a terminal is the same as that for normal operation. A spare receiver used as the diversity receiver and a separate surface-wave

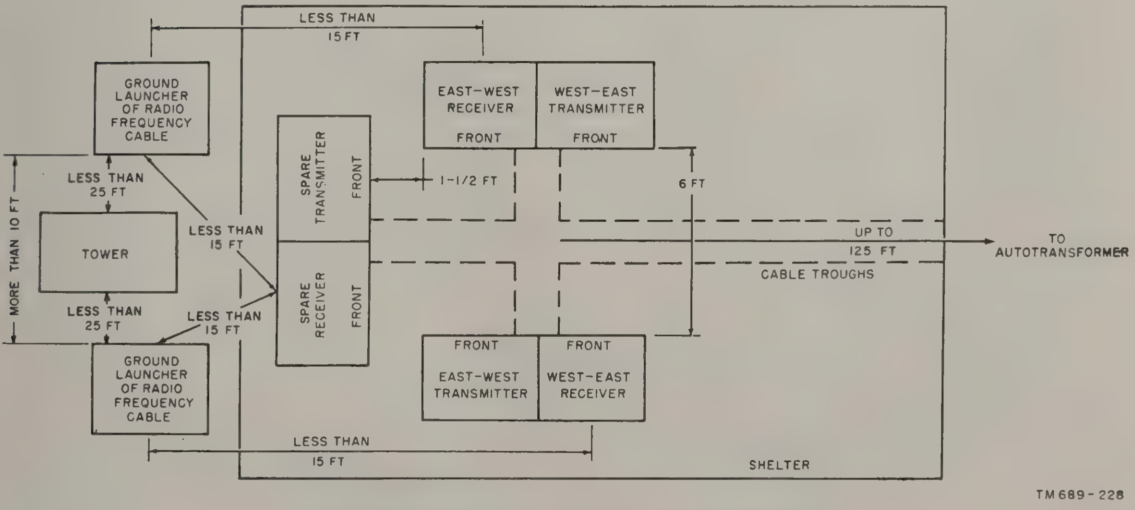

LESS THAN 15 FT
GROUND LAUNCHER OF RADIO FREQUENCY CABLE
EAST–WEST RECEIVER FRONT
WEST–EAST TRANSMITTER FRONT
SPARE TRANSMITTER FRONT
1-1/2 FT
6 FT
LESS THAN 25 FT
MORE THAN 10 FT
TOWER
LESS THAN 15 FT
UP TO 125 FT
TO AUTOTRANSFORMER
CABLE TROUGHS
SPARE RECEIVER FRONT
LESS THAN 25 FT
LESS THAN 15 FT
FRONT EAST–WEST TRANSMITTER
FRONT WEST–EAST RECEIVER
GROUND LAUNCHER OF RADIO FREQUENCY CABLE
LESS THAN 15 FT
SHELTER
TM 689-228

Figure 57. Proposed through repeater station layout.

transmission line and antenna are used for each receiver rack. The two ground launchers should be about 10 feet apart and between 10 and 20 feet from the tower, permitting the 15-foot cable to be connected to their associated receiver racks.

(2) *Repeater stations.* A proposed layout for repeater stations using diversity operation is shown in figure 59. The station layout differs from the usual arrangement in that the spare radio set (receiver now called standby receiver) is placed alongside its associated operating radio set (receiver now called preferred receiver). Each of these receivers uses a separate surface-wave transmission line and antenna. The two launchers should be about 10 feet apart and between 10 and 20 feet from the tower, permitting connection to their associated receiver racks.

f. Operation Without Duplexer. To operate without a duplexer, a separate surface-wave transmission line and antenna are used for the transmitter and the receiver. Two launchers are used for each direction, and should be about 10 feet apart. Otherwise, the basic station layout requirements are the same as for operation with a duplexer.

g. Location of Autotransformer and Switchbox. Locate the autotransformer and switchbox within 15 feet of each other and within 10 feet of the primary power source. They must also be located within 125 feet of the transmitter rack and placed as close to this rack as possible.

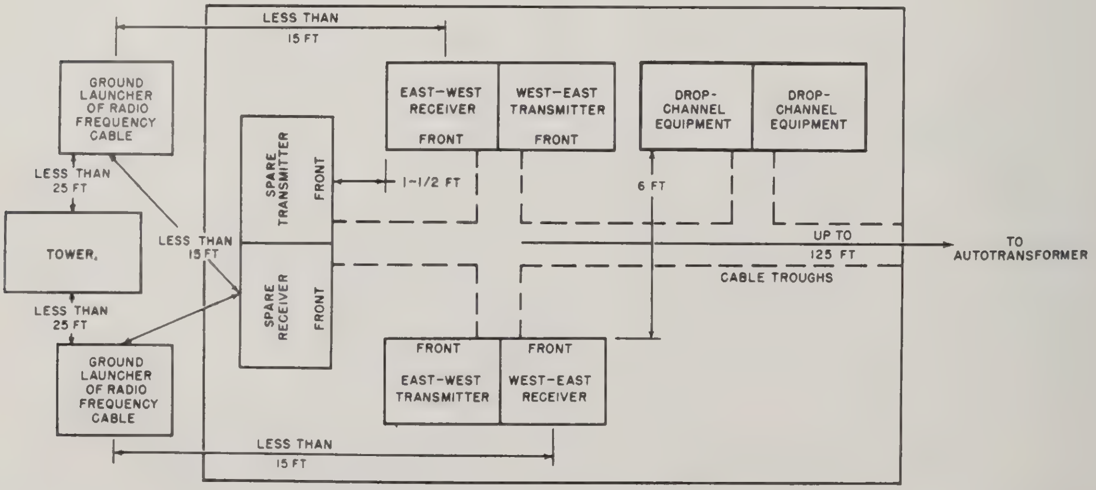
47. Uncrating, Unpacking, and Checking New Equipment

Note. For used or reconditioned equipment, refer to paragraph 52.

a. General. The components of Radio Set AN/TRC–29 may be shipped in oversea packing cases, in domestic packing cases, and sometimes in their own carrying cases. When new equipment is received, be sure that the proper number of crates are received. The instructions in *b* below apply to equipment shipped in export packing cases. The instructions in *f* below apply to equipment shipped in domestic packing cases. Be sure that all carrying cases are present and that the equipment is undamaged; no special unpacking and uncrating procedures are necessary for equipment shipped in carrying cases.

Caution: Be careful when uncrating, unpacking, and handling equipment; it is easily damaged. If it becomes damaged or exposed, a complete overhaul might be required or the equipment might be rendered useless.

b. Step-by-Step Instructions for Uncrating and Unpacking Export Shipments (fig. 60).


LESS THAN
15 FT
GROUND LAUNCHER OF RADIO FREQUENCY CABLE
EAST-WEST RECEIVER
FRONT
WEST-EAST TRANSMITTER
FRONT
DROP-CHANNEL EQUIPMENT
DROP-CHANNEL EQUIPMENT
LESS THAN 25 FT
SPARE TRANSMITTER
FRONT
1-1/2 FT
6 FT
TOWER.
LESS THAN 15 FT
UP TO
125 FT
TO AUTOTRANSFORMER
CABLE TROUGHS
SPARE RECEIVER
FRONT
LESS THAN 25 FT
FRONT
FRONT
EAST-WEST TRANSMITTER
WEST-EAST RECEIVER
GROUND LAUNCHER OF RADIO FREQUENCY CABLE
LESS THAN
15 FT

TM 689-229

Figure 58. Proposed drop-channel station layout.

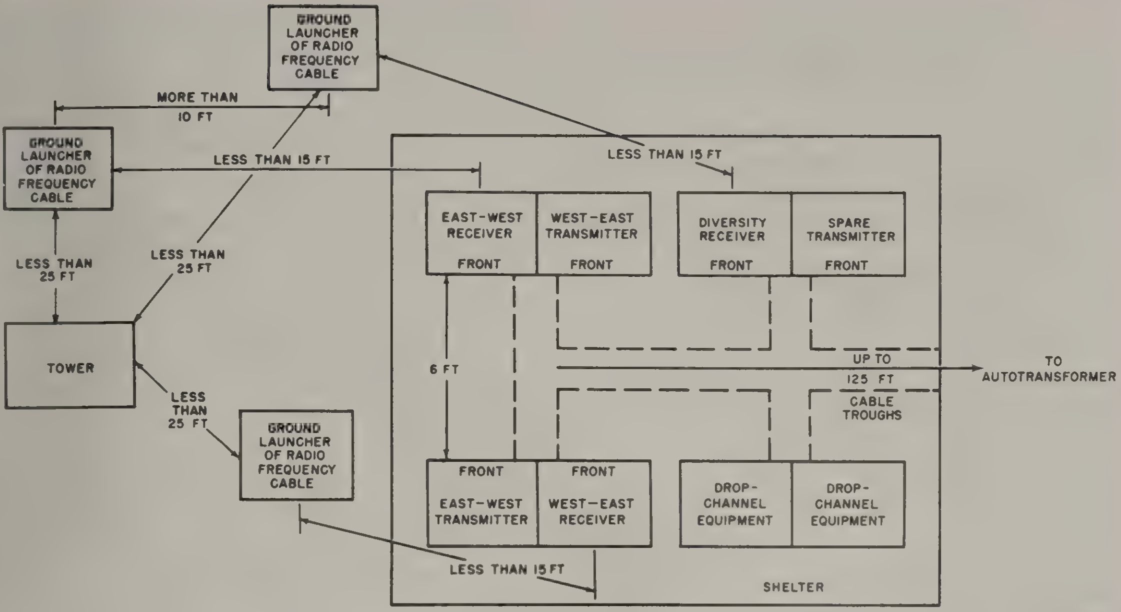

GROUND LAUNCHER OF RADIO FREQUENCY CABLE
MORE THAN 10 FT
GROUND LAUNCHER OF RADIO FREQUENCY CABLE
LESS THAN 15 FT
LESS THAN 15 FT
LESS THAN 25 FT
LESS THAN 25 FT
TOWER
LESS THAN 25 FT
GROUND LAUNCHER OF RADIO FREQUENCY CABLE
EAST-WEST RECEIVER FRONT
WEST-EAST TRANSMITTER FRONT
DIVERSITY RECEIVER FRONT
SPARE TRANSMITTER FRONT
6 FT
UP TO 125 FT
TO AUTOTRANSFORMER
CABLE TROUGHS
FRONT EAST-WEST TRANSMITTER
FRONT WEST-EAST RECEIVER
DROP-CHANNEL EQUIPMENT
DROP-CHANNEL EQUIPMENT
LESS THAN 15 FT
SHELTER
TM 689-230

Figure 59. Proposed station layout for diversity operation at a repeater.

(1) Separate the packing crates into the following four categories:

  (*a*) Crates containing the transmitter rack, receiver rack, and spare parts of Radio Set AN/TRC–29 (crates No. 1–4 (par. 15*a*)).

  (*b*) Crates containing antenna rf cable assembly, autotransformer, and reel (crates No. 5–13 (par. 15*a*)).

  (*c*) Tower AB–216/U crates.

  (*d*) Crates containing video equipment (when used). Reference should be made to the video equipment manual for unpacking and uncrating instructions.

(2) Cut and fold back the steel straps.

(3) Remove the nails with a nail puller. Remove the top and one side of the packing case. Do not attempt to pry off sides and top; the equipment may be damaged.

(4) Remove the waterproof metal container (*d* below) or moistureproof barrier and any excelsior or corrugated paper covering the equipment inside the case.

(5) Carrying cases that contain the transmitter and receiver racks should be placed in their final position. The equipment can be carried by the three carrying handles on each side of the case.

(6) Inspect the equipment for possible damage incurred during shipment.

(7) Check the contents of packing case against the master packing slip.

c. Opening Cardboard Carton and Waterproof Barrier. No special instructions are needed for opening the waterproof paper barrier and removing equipment from the cardboard carton.

d. Instructions for Opening Metal Containers. The top of the metal container is soldered to the sides. To open, break the soldered seam by prying the side of the container away from the soldered seam as follows:

(1) Wipe off the excess solder with a soldering iron. Never use a torch because the contents of the case may be inflammable.

(2) With a wooden block or screwdriver, pry the sides from the soldered seam.

(3) When the seam is completely open, pry off the cover.

(4) Remove the bags of desiccant and the

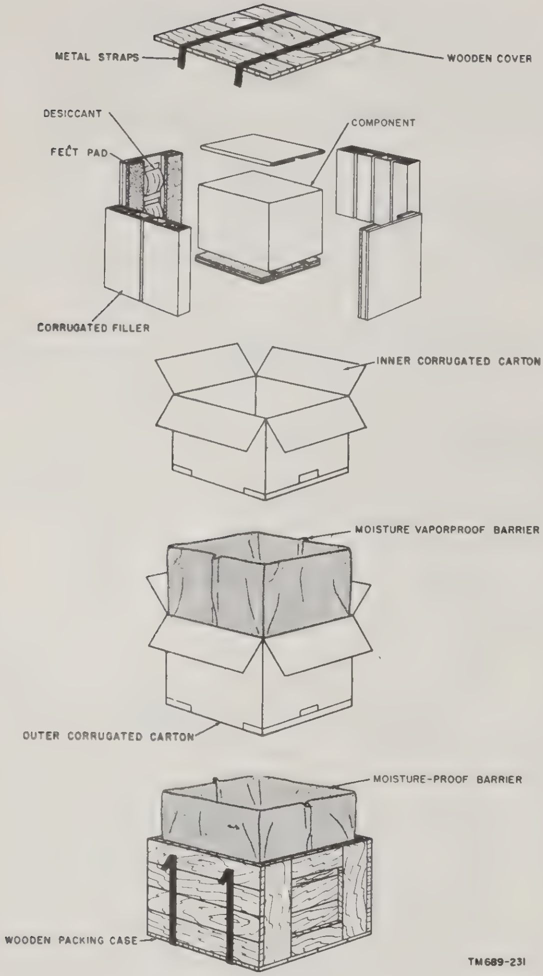


Figure 60. Typical packing and packaging diagram for small cases.

protective cardboard packing and lift or draw out the package within.

e. Checking. Check the contents against the master packing slip.

f. Unpacking Domestic Packing Crates. The radio set may be received in domestic packing cases. The instructions in *b* above apply also to unpacking domestic shipments. Cut the metal bands. Open the cartons that protect the equipment; or, if heavy wrapping has been used, remove it carefully and take out the components. Check the contents of the packing case against the master packing slip.

g. Step-by-Step Instructions for Uncrating Two Equipment Racks (fig. 61).

(1) Place the packing crates for two equipment racks as near the operating position as convenient.

(2) Remove the nails from the wooden crate top and one end with a nail puller. Prying off the top may cause damage to the equipment.

(3) Remove the nails from the remaining sides of the crate with a nail puller.

(4) Cut the barrier and remove the corrugated cover.

(5) Remove the end fillers and desiccant.

(6) Cut each of the three strappings.

(7) Using the carrying handles (fig. 5), remove the cases. Since these weigh as much as 534 pounds, seven men may be necessary.

(8) Place the cases at the desired locations.

(9) Inspect the equipment for possible damage incurred during shipment.

(10) Check the contents of each packing case against the master packing list.

h. Removal of Covers from Transmitter and Receiver Rack Carrying Cases. Remove the carrying cases from the transmitter and receiver rack as follows:

(1) Be sure that the equipment is facing front by noting the position of the carrying handles. The open (or handling) end of the handle is toward the rear of the equipment (so that when the case is carried, the rear is always facing downward).

(2) Remove the front and back covers by unlocking the four latches on each side of the carrying case and the two on top that secure each cover.

(3) Open all front doors and inspect the equipment for damaged parts.

(4) Be sure that the INPUT POWER BREAKERS at the rear of the high-voltage power supply (lowest component on the transmitter rack) are in OFF position.

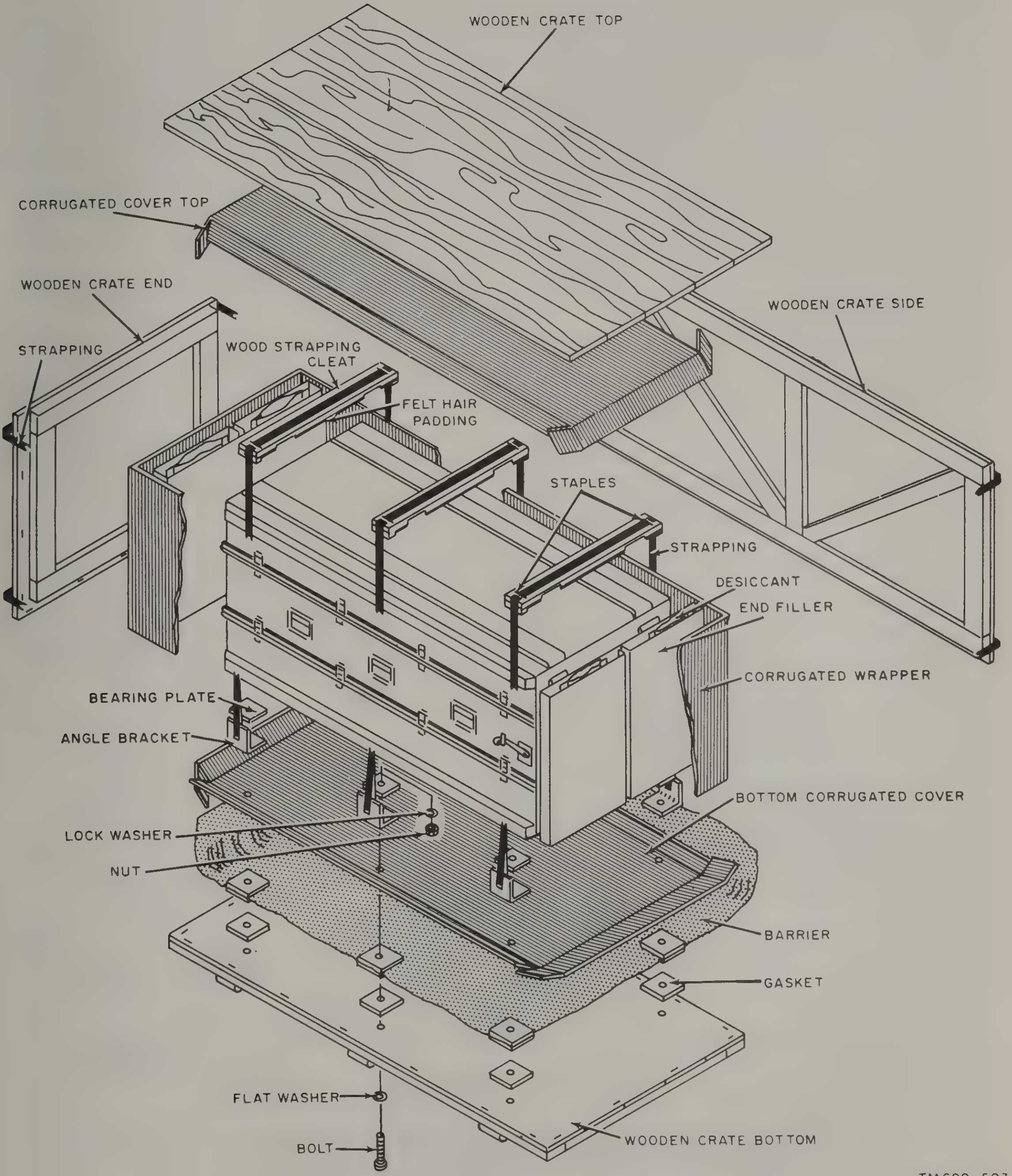

WOODEN CRATE TOP
CORRUGATED COVER TOP
WOODEN CRATE END
STRAPPING
WOOD STRAPPING CLEAT
FELT HAIR PADDING
WOODEN CRATE SIDE
STAPLES
STRAPPING
DESICCANT
END FILLER
CORRUGATED WRAPPER
BEARING PLATE
ANGLE BRACKET
BOTTOM CORRUGATED COVER
LOCK WASHER
NUT
BARRIER
GASKET
FLAT WASHER
BOLT
WOODEN CRATE BOTTOM
TM689-503

Figure 61. Typical packaging diagram for equipment rack crates.

48. Installation of Tower AB–216/U

Install the tower to the necessary height (par. 40) in accordance with the procedure in TM 11–5073. The wide sides of the tower should face the general direction of the next stations.

49. Installation of Antenna AS–554/TRC–29

a. General. Antenna AS–554/TRC–29 is shipped in five cases (par. 15*a*) as shown in figure 15. The contents of these crates should be checked against the master packing list. Install the antenna as follows:

Note. Before erecting the antenna, determine the antenna polarization, tilt angle, and azimuth from the work sheet (par. 44 and fig. 29).

b. Assembly of Antenna on Ground. Assemble the antenna on the ground as follows:

(1) Unpack all cases but cases No. I and arrange them on the ground (fig. 62)

(2) Assemble the four quarter sections of the parabolic antenna facing downward. Sections are bolted to each other through six matching holes. Do not overtighten the bolts.

(3) Assemble the yoke, consisting of the split clamp casting, two curved half-yoke sections, support pipe, T-clamp, and left and right end casting and swivel clamps as shown in figure 63. The parts are positioned by guide pins.

(4) Insert the two bearing castings in the end castings and attach the yoke to the parabolic dish (fig. 64). The split clamp should be on the side away from the hoisting shackle.

(5) Attach the detent tilt bar between the split clamp and the dish, using the outer rear hole of the four bearing casting mounting holes; lock it in position with the yoke as high as possible. Attach two swivel clamps to the ends of the support pipe section with the axis of rotation parallel to the plane of the curved half-yoke pipes.)

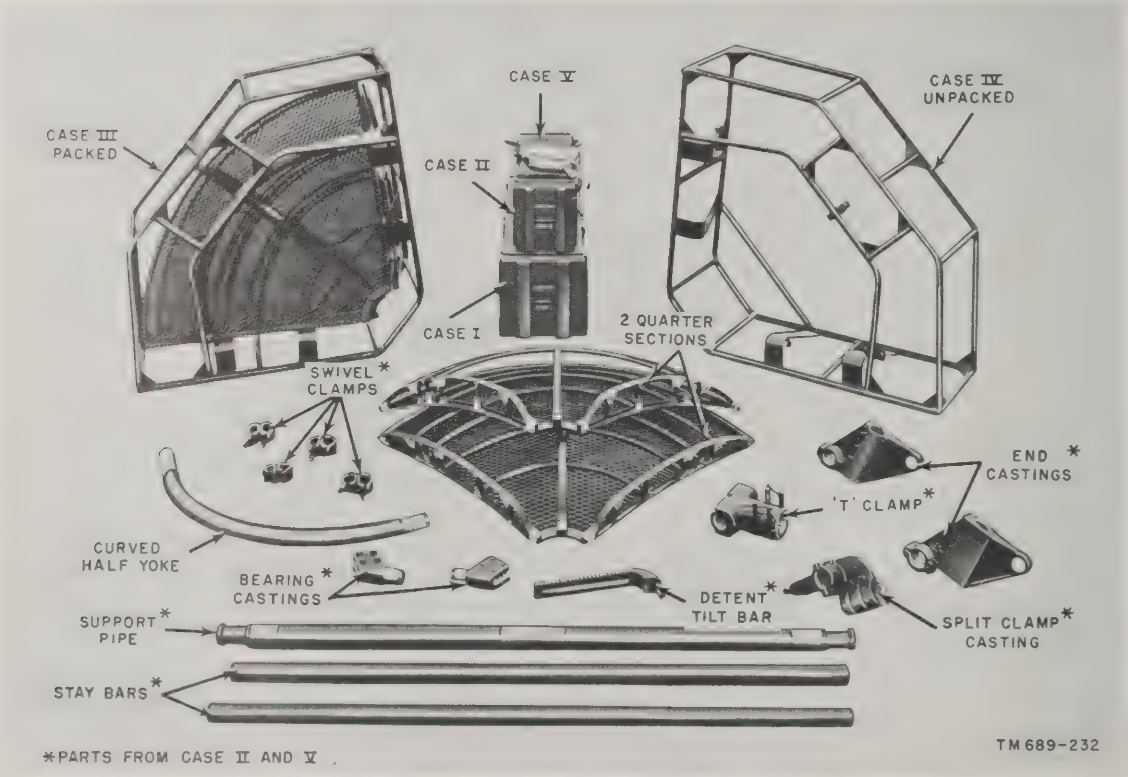

CASE V
CASE IV UNPACKED
CASE III PACKED
CASE II
CASE I
2 QUARTER SECTIONS
SWIVEL CLAMPS *
END CASTINGS *
'T' CLAMP *
CURVED HALF YOKE
BEARING CASTINGS *
DETENT TILT BAR *
SUPPORT PIPE *
SPLIT CLAMP CASTING *
STAY BARS *
*PARTS FROM CASE II AND V.
TM 689-232

Figure 62. Arrangements of antenna parts on ground.

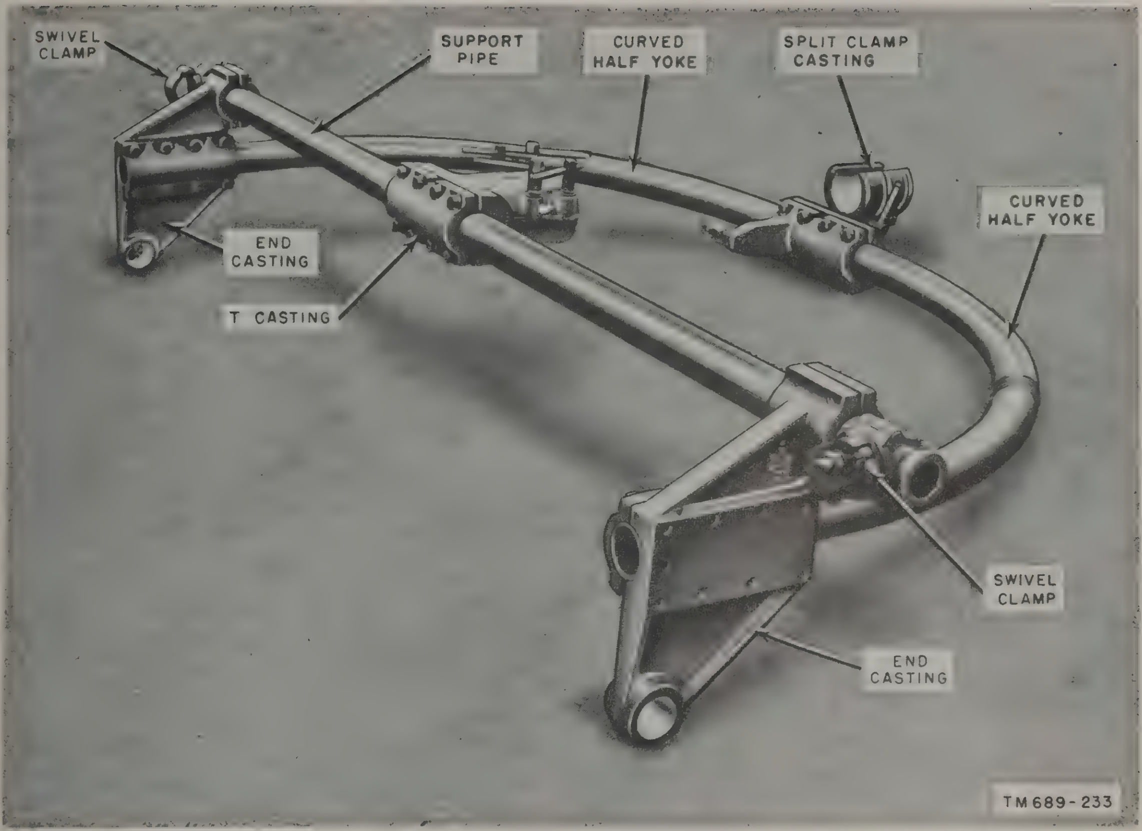


Figure 63. Yoke assembly.

(6) Insert the A-frame post of Tower AB–216/U in the T-casting, and rotate the post until the cross bar in the casting drops into the slots in the post.

(7) Loosen the T-casting bolts until the A-frame post is properly seated in the split clamp and tighten all bolts.

(8) Remove the stack of pipe inserts from the A-frame post, and leave the sleeve ring bolted in the retaining hole. Remove the unused bolt near the midpoint of the A-frame post. Figure 64 shows the assembled yoke and parabolic antenna as it should appear at this point.

Note. The white parts are supplied with Tower AB–216/U.

(9) Carefully note how the parabolic antenna fits on the A-frame post. In the next step, the A-frame post is removed from the parabolic antenna assembly and placed in the A-frame. The through bolt of the sleeve ring must be mounted midway between the jaws of the A-frame clamp (fig. 65). The A-frame is hoisted and mounted on the tower. The antenna is then hoisted on the tower and placed on the post. For obvious reasons, it is important to be able to mount the antenna on the post quickly and readily after it is hoisted up on the tower.

(10) Remove the A-frame post from the parabolic antenna and attach it to the A-frame by the clamps provided. Be sure that the sleeve ring is against the bottom clamp of the A-frame (fig. 66).

c. Raising A-Frame and Antenna. Raise and mount the A-frame and antenna on the tower as follows:

(1) Mount heavy duty davit MX–1215/U as high as possible on the tower for

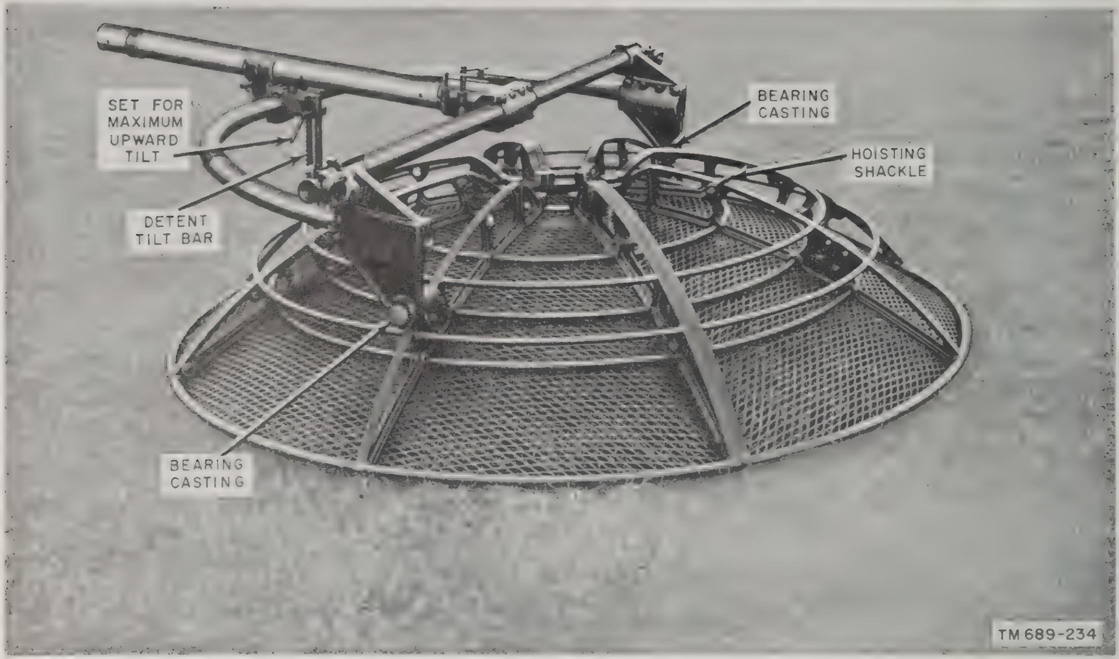


Figure 64. Assembled yoke and parabolic antenna.

tower top mounting or 8 feet above the desired dish level for lower mountings.

Note. Determine whether the davit supplied is to be mounted on the right or left tower post. The figures show the right hand mounting. Always be sure that the boom can swing to a position directly above the desired A-frame position.

(2) Rig the A-frame for hoisting with hoist and tag lines. Tie the tag lines on the end castings so that they can be removed from the tower top. The post end which held the pipe inserts must be down.

(3) Mount the A-frame with the top support leg at least 18 inches (for top tower mounting) below the joint that separates the top tower section mounting the hoist boom and section mounting the A-frame; or at least 8 feet below the joint that holds the hoist for lower mountings (fig. 67).

(4) Attach the antenna dish to the hoist line and take up the slack until the dish is vertical, with the lower edge resting on the ground.

Note. Attach the rope to the hoist eye (fig. 68) to prevent the hook from slipping out of the lifting shackle.

(5) Tie two tag lines on the support castings.

(6) Be sure the tilt bar adjustment is locked to tilt the dish upward as far as possible. Failure to do this will prevent attaching the yoke to the A-frame because of interference with the upper A-frame post clamp.

(7) Hoist the antenna assembly in place, lowering the T-casting over the top of the A-frame post. See figure 68.

Note. Aline the antenna assembly and post as described in *b*(5), (6), and (7) above. To prevent the A-frame from turning, insert a crescent wrench handle or screwdriver blade between the small pipe and the large pipe post; use this handle as a lever.

(8) When the dish is seated in position, tighten all hand clamps on the T and split clamp castings. Tilt the antenna downward as far as possible after loosening the tilt bar adjustment.

(9) Use the tag line for guidance and hoist

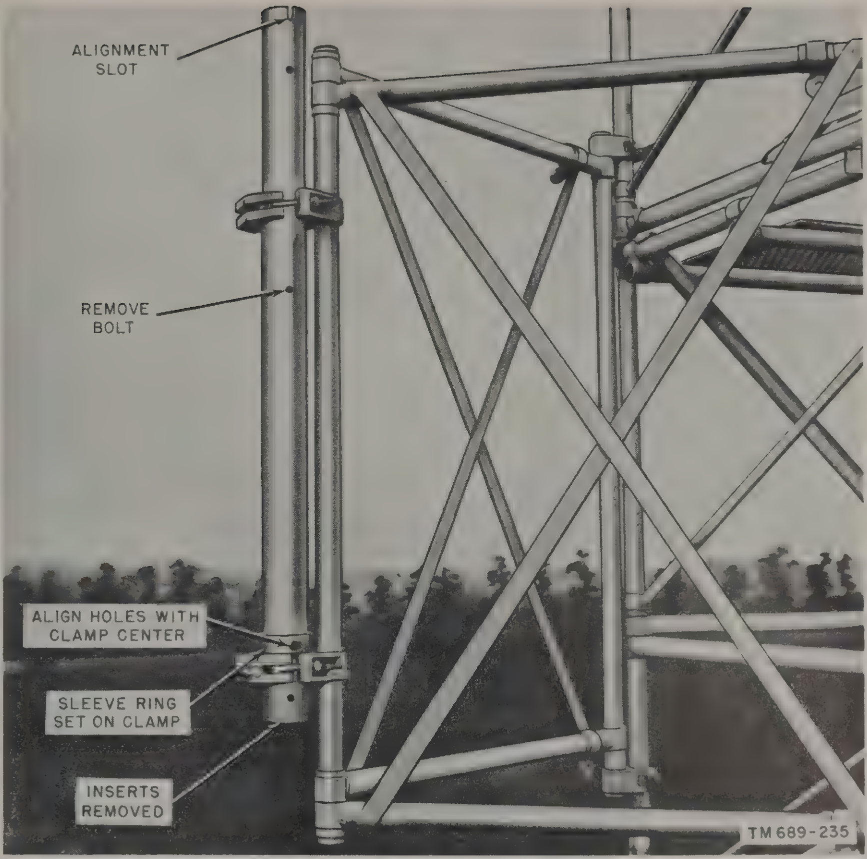


Figure 65. A-frame post mounted on A-frame.

the feed horn with the antenna feed cable attached (fig. 69).

(10) From the installation work sheet, determine whether the feed horn is to be horizontally or vertically polarized (par. 44*c*). Insert the feed horn in the antenna dish from the rear so that the proper polarization is obtained (as indicated by an arrow on the feed horn support) and bolt the horn in place (fig. 70). The 6-inch extension of the feed horn support can be used as a level for keeping the horn in place when seating and starting the bolts.

d. Adjusting Antenna. Adjust the antenna tilt and azimuth as follows:

(1) Adjust the tilt bar for an antenna angle as called for on the worksheet. Each notch is 1° (fig. 71).

(2) Attach a swivel clamp to one end of each of the 7-foot stay bars included in case No. 5.

(3) Use the hoist rope and tag line to hoist the bars to the antenna position.

(4) Rotate the antenna to bring one end closer to the tower. Insert the stay bar in the swivel on the support pipe of the antenna and clamp it as shown in figure 72. Loosen the half of the clamp on the antenna support pipe until it can be rotated under pressure.

(5) Use the first stay bar as a push rod to rotate the antenna, and then attach the second stay bar to the other clamp ((4) above).

(6) Set the antenna for the desired azimuth; use the stay bars as push rods. Clamp the ends of the stay bars to the tower wherever convenient; be sure that they do not interfere with travel

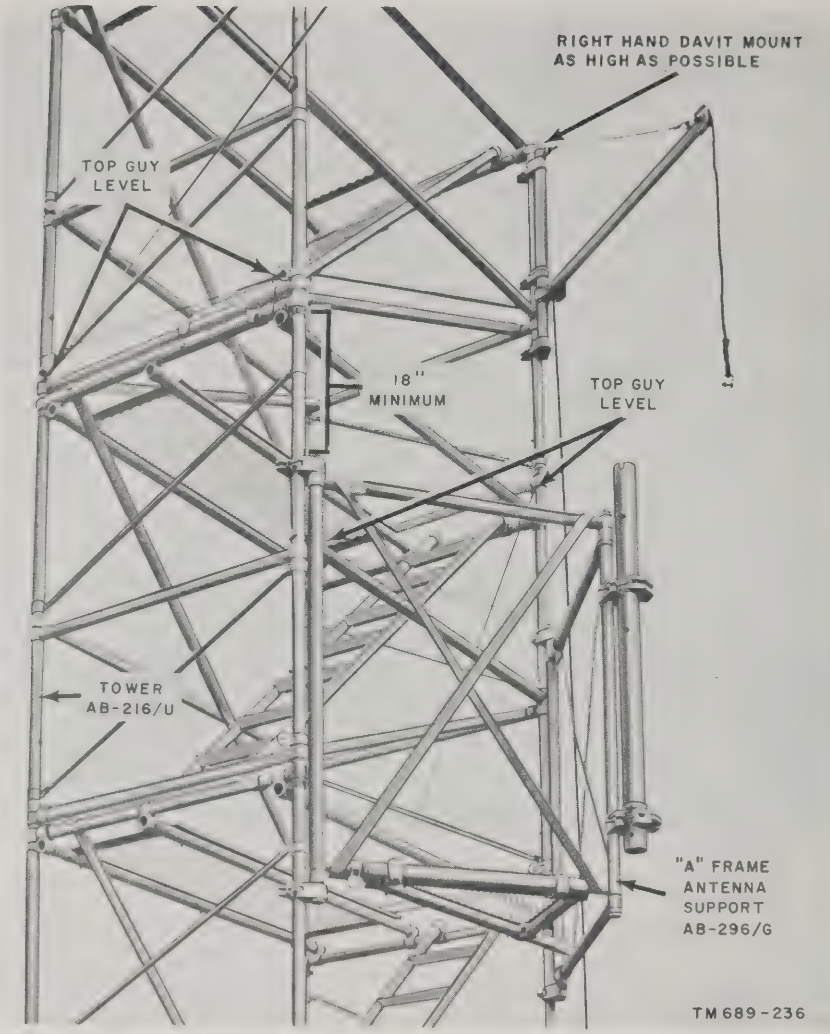

RIGHT HAND DAVIT MOUNT AS HIGH AS POSSIBLE
TOP GUY LEVEL
18" MINIMUM
TOP GUY LEVEL
TOWER AB-216/U
"A" FRAME ANTENNA SUPPORT AB-296/G
TM 689-236

Figure 66. Tower top hoist and A-frame mounting.

in the walkway. The antenna assembly is now complete.

50. Installation of Radio Frequency Transmission Line Assembly CG–1013/U

Before installing Radio Frequency Transmission Line Assembly CG–1013/U, refer to typical installation (fig. 73) so as to become familiar with the parts and proceed as follows:

a. Determine the most suitable place to mount the launching unit. The launching unit must be placed within 10 feet of the center of the parabolic antenna. Find a location that affords a clear space with at least a 5-foot radius around the transmission line, *which is clear of guys or metal objects,* and which will permit mounting the lower launching unit within 20 feet of the base of the tower (maximum distance permitted by the 25-foot cable assembly) and 10 feet from the radio equipment (maximum distance permitted by the 15-foot rf feed cable to the radio set). Near the launcher, the space within a cone formed by the imaginary extension of the launching unit cone must be clear of metal objects.

b. When Tower AB–216/U is used, the upper

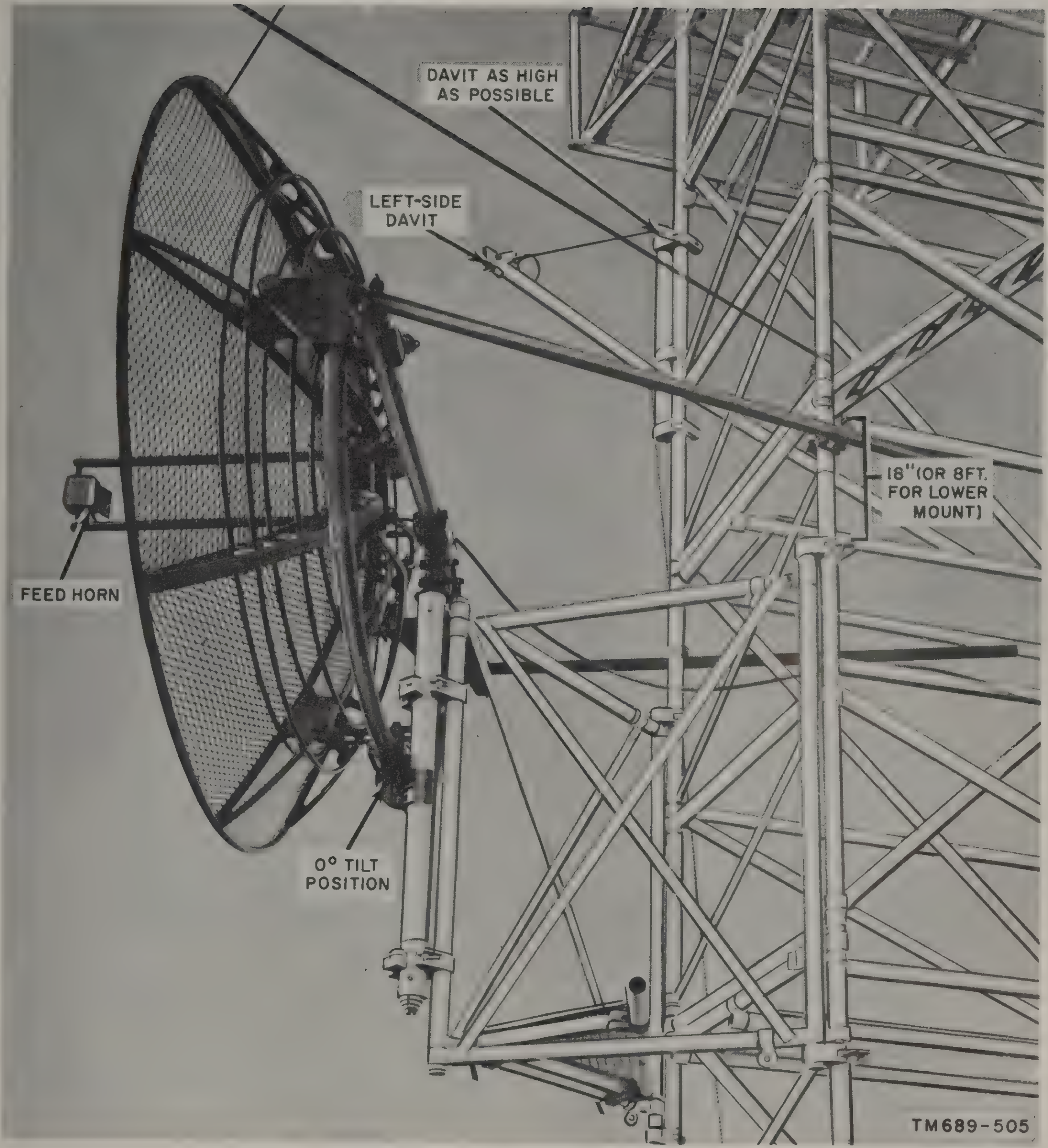

DAVIT AS HIGH AS POSSIBLE
LEFT-SIDE DAVIT
18"(OR 8FT. FOR LOWER MOUNT)
FEED HORN
0° TILT POSITION
TM689-505

Figure 67. A-frame rig for hoisting.

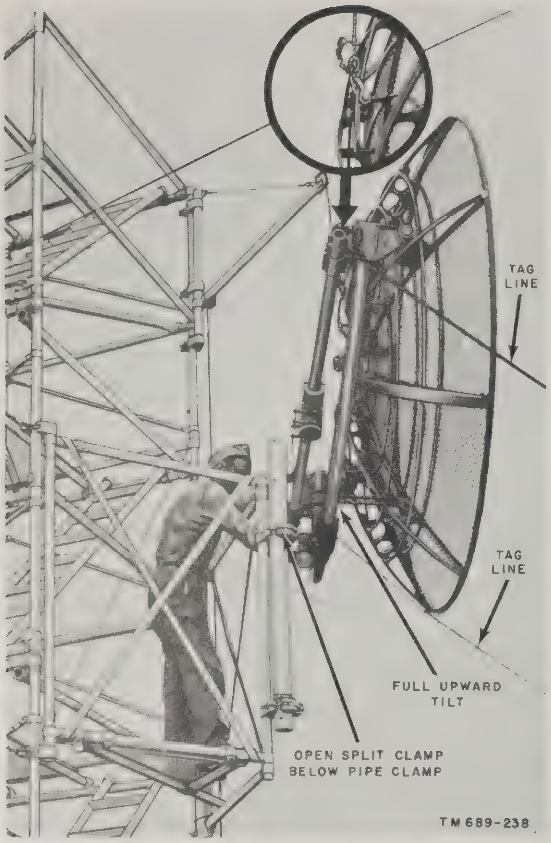


Figure 68. Hoisting rope rigged for hoisting antenna.

launching unit of the surface-wave transmission line should be connected to one of the tower guy wire straps or to a suitably located strap on the A-frame of Antenna Support AB–296/G. For unusual situations, the large clevis is supplied for use in place of the strap on the tower.

c. When more than one transmission line is attached to a tower, at least a 10-foot separation must be maintained between parallel lines. The 6-foot tower width may be used between lines which diverge from 6 feet on the tower to not less than a 15-foot separation on the ground end.

d. Remove one transmission line, one launching unit, and the 5-foot power cable assembly from the transit case and prepare them for installation as follows:

Caution: Do not allow any kinks to form in the transmission line wire. Kinks will cause the wire to become weak and break during final tightening of the transmission line.

(1) Strip approximately 4 inches of polyethylene dielectric from one end of the transmission line.

(2) Unclip the rope assembly (fig. 74) on the launching unit. Separate the cone and fiberglas shield from the housing by turning the fire hose connector.

(3) Carefully feed the bared end of the transmission line through the small hole in the end of the fiberglas shield for a distance of several feet (A, fig. 75). One man should support the cone and wire while a second man performs the next operation.

(4) Slip the stripped end of the transmission line through the hole at the end of the connecting tip as shown in figure 74 until the insulation touches the tip.

Caution: Do not force the wire through the tip holes or allow the wire to be bent out of alignment with the holes. Misalignment as shown in B, figure 75 will break the tip.

(5) Grasp the wire and the tip as shown in A, figure 75 to prevent movement and possible tip damage. Note where the center line of the hole through the shank of the connecting tip meets the bare wire (C, fig. 75). At that point, bend the bare wire at right angles toward the connecting tip with pliers. Clip the excess wire off until only one-half inch remains. Press this bent end of the wire through the hole in the shank and press the remaining bared wire into the groove along the connecting tip. Cut off any excess wire protruding through the hole in the shank.

(6) Screw the launcher on the tip shank; be careful not to rotate the transmission line and shank. See D, figure 75.

(7) Carefully slide the cone assembly (fig. 74) along the wire and reassemble it to the housing.

Note. The two mounting ends of the rope assembly should line up.

(8) Connect one end of the 5-foot power cable assembly to the terminal at the large end of the cone and tighten the wingnut. Temporarily tape the power

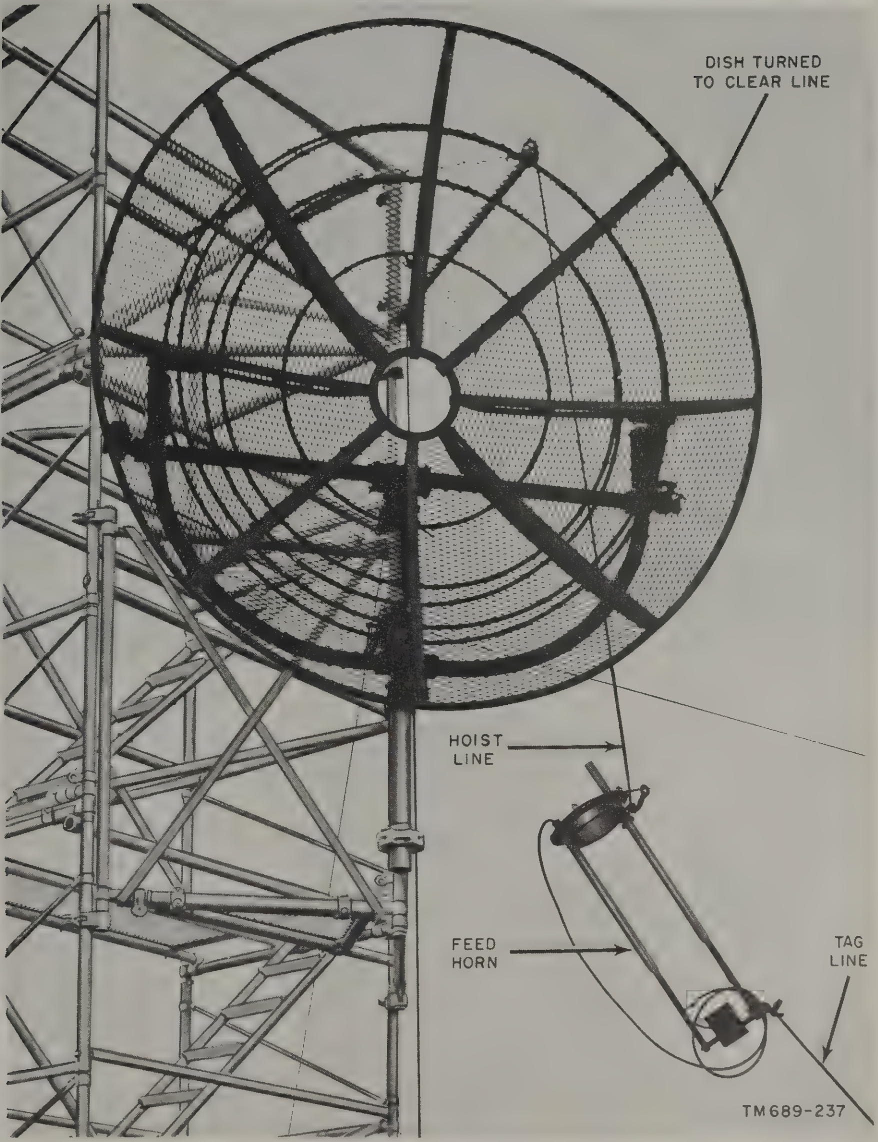

DISH TURNED
TO CLEAR LINE
HOIST
LINE
FEED
HORN
TAG
LINE
TM689-237

Figure 69. Hoisting feed horn.

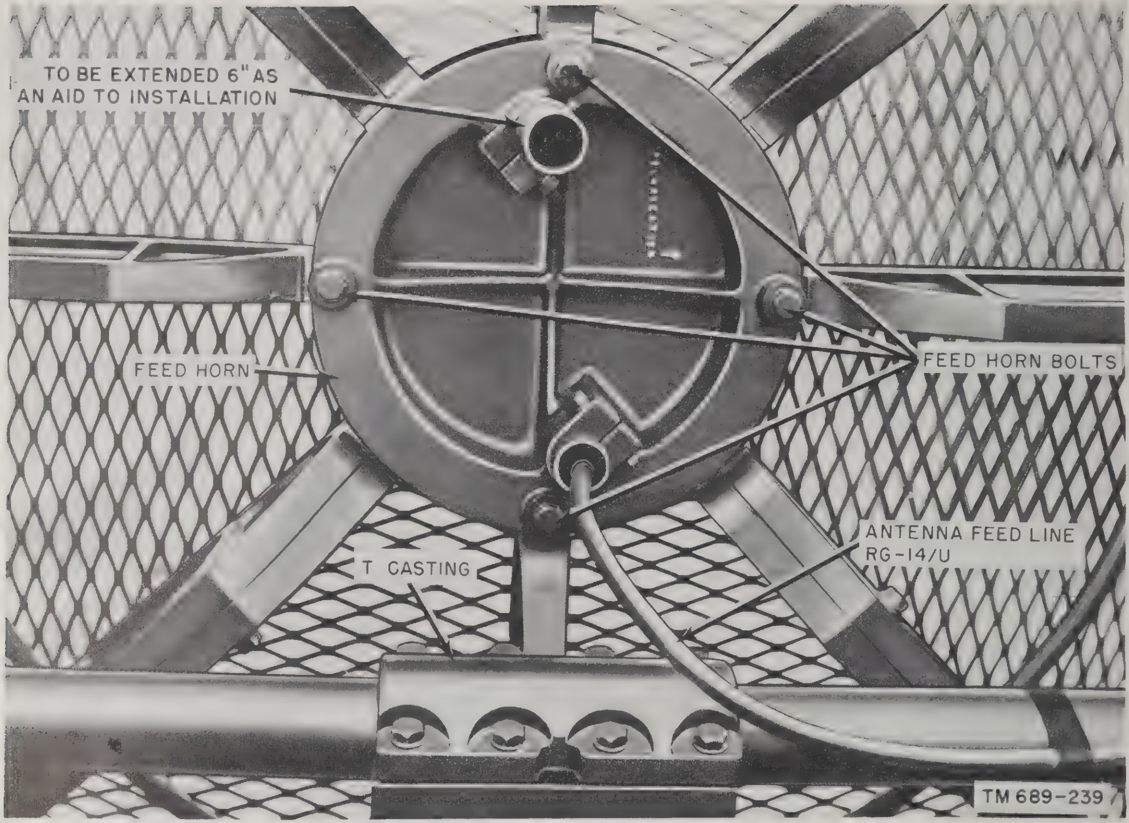

TO BE EXTENDED 6" AS AN AID TO INSTALLATION
FEED HORN
FEED HORN BOLTS
ANTENNA FEED LINE RG-14/U
T CASTING
TM 689-239

Figure 70. Feed horn mounting.

cable assembly to the housing, with a few inches of tape hanging loose. This permits the cable to be recovered at the top of the tower.

e. Using the hoist rope of the tower connected to the clevis at the end of the launching unit, carefully hoist the launching unit to the antenna position.

Caution: Pay out the transmission line carefully. Do not allow kinks to form.

f. Connect the launching unit mounting to the tower strap selected in *a* above.

g. Connect the 5-foot power cable assembly to the nearest grounding stud (above the tower guy strap) on Tower AB–216/U. Be sure that all paint masking paper is removed from the stud and that a bare metal contact is made with the cable lug. On other types of towers, a suitable electrical grounding clamp will be required.

Caution: To make a good electrical contact, the connecting point on the tower should be free from paint and corrosion.

h. Connect the 10-foot rf cable assembly (antenna feed) to the antenna. Antenna AS–554/TRC–29 supplied with Radio Set AN/TRC–29 has its own coaxial cable and the 10-foot rf cable assembly supplied with the surface-wave transmission line assembly is not used.

i. To connect the rf cable assembly from the antenna to the launching unit, unscrew the cap on the coaxial assembly mounted on the housing (fig. 74) and screw on the rf cable connector plug. Screw the connector cover cap to the cap holder on the launching unit housing.

j. Tape the rf connector with a good grade of electrical tape (rubber or plastic) to seal the connection from dirt and moisture and to prevent vibration from loosening the connector. Provide drip loops for both cables, and tape them to the tower to prevent wind whipping.

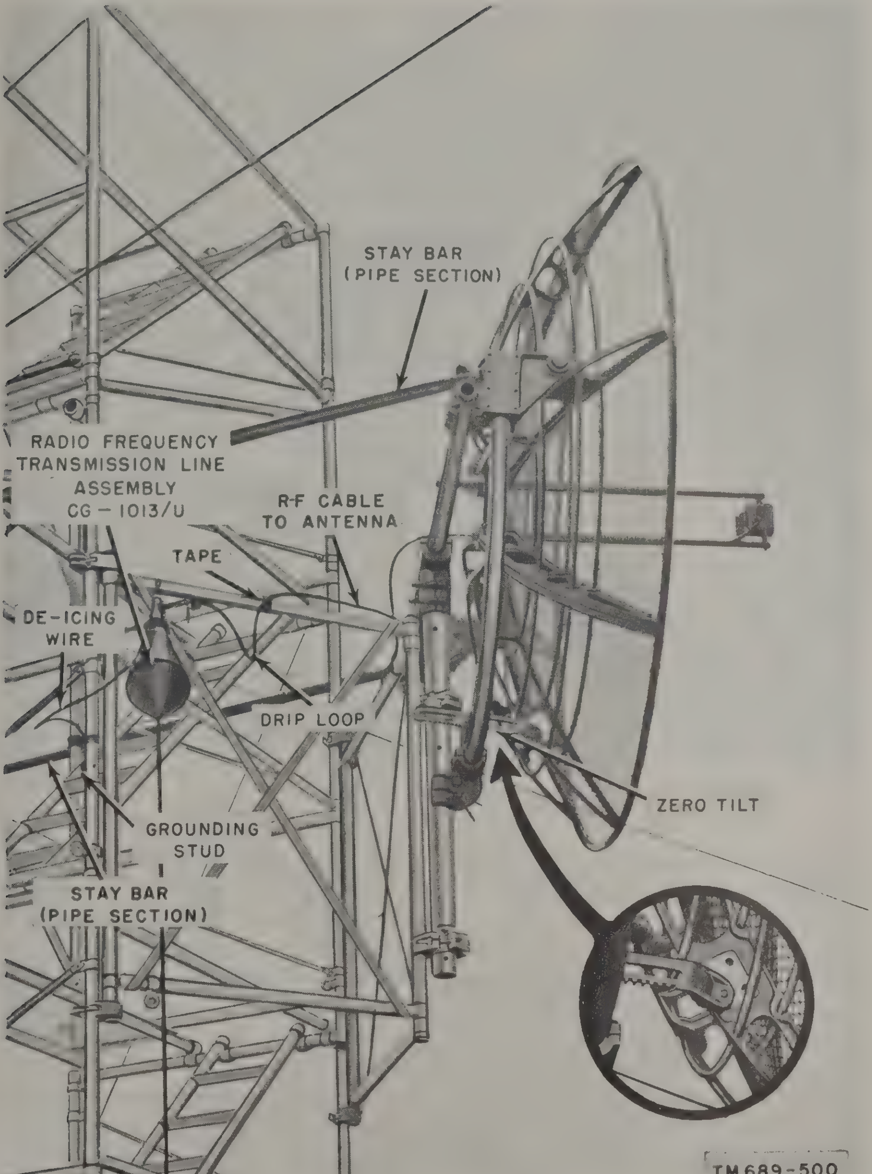

STAY BAR
(PIPE SECTION)
RADIO FREQUENCY
TRANSMISSION LINE
ASSEMBLY
CG-1013/U
R-F CABLE
TO ANTENNA
TAPE
DE-ICING
WIRE
DRIP LOOP
ZERO TILT
GROUNDING
STUD
STAY BAR
(PIPE SECTION)
TM689-500

Figure 71. Antenna mounted on tower.

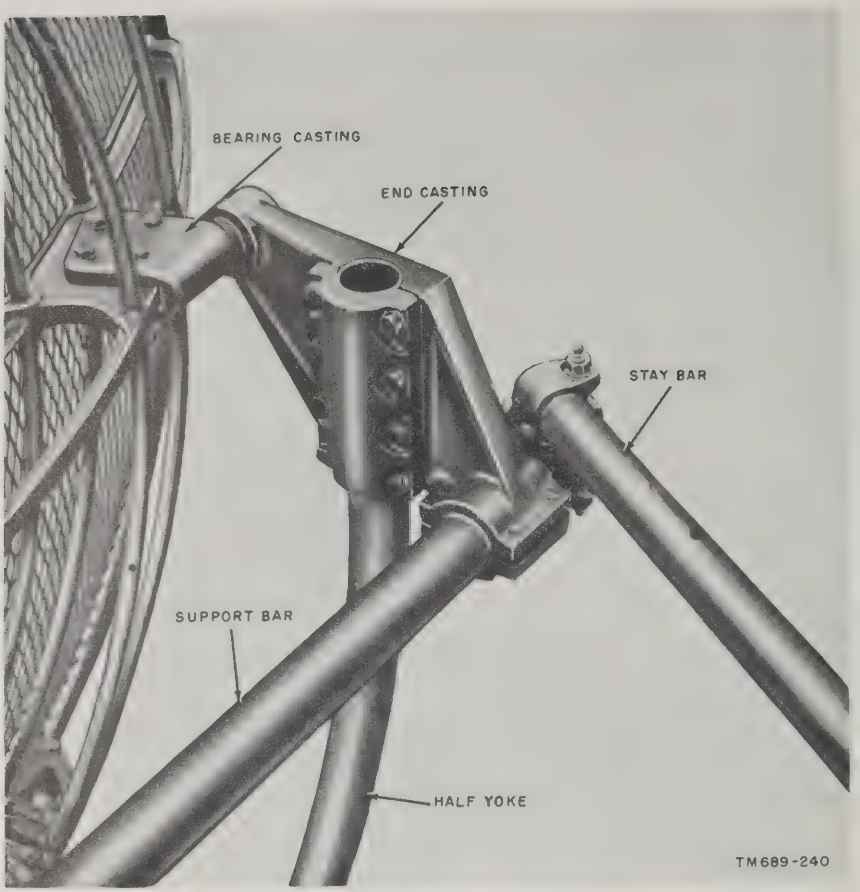


Figure 72. Stay bar clamp.

k. Remove the parts required for the bottom launcher mounting from the transit case at the ground point selected in *a* above.

l. If a ground mount is desired, screw the anchor screw into the ground. If the guy assembly is to be mounted to the side of a building, drill a ½-inch hole through the wall and place the eyebolt through the wall. Place a washer on each side of the wall and tighten the assembly.

Note. If the ground is very hard or frozen, use Guy Stake GP–112 with the small clevis and drive it into the ground with a hammer.

m. Attach one end of the turnbuckle to the ground mount or eyebolt, whichever is used, and attach the snubit clamp to the other end of the turnbuckle. Snap the guy wire to the lower eye of the tensioning spring.

n. Attach the launching unit to the tensioning spring of the guy assembly. Be sure that the end of the tensioning spring marked *THIS END UP* is next to the launching unit to prevent water and dirt from entering the spring.

o. Release the snubit clamp in the guy assembly and extend the guy wire to its maximum length. Open the turnbuckle sleeve to its maximum length so that it may be used to tension the guy wire.

p. Measure the required length of transmission line required and cut away the remainder.

Caution: Do not cut the transmission line exactly to the length required. Leave an extra foot or two and pick up the slack by shortening the guy wire.

q. Repeat the instructions given in *b* above and connect the transmission line to the bottom launching unit.

r. Pull the lower end of the guy wire until the transmission line is tight and under tension

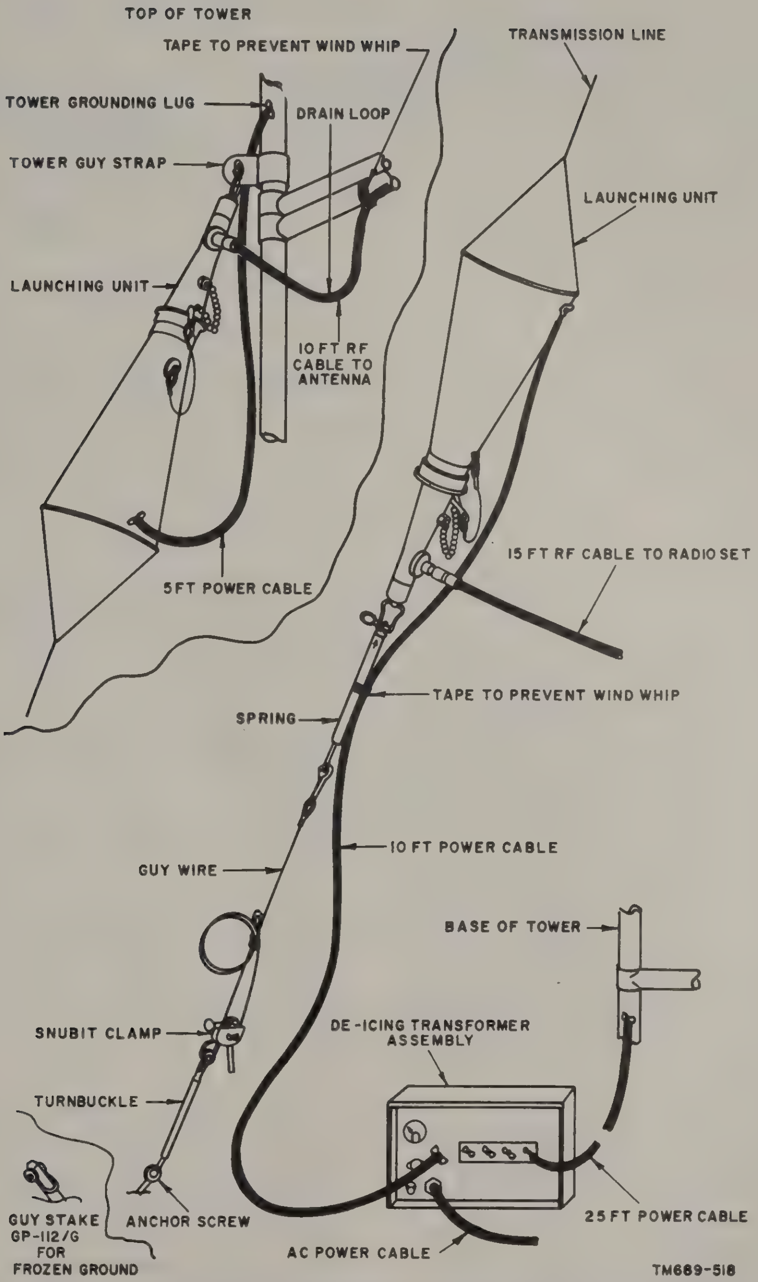

TOP OF TOWER
TAPE TO PREVENT WIND WHIP
TRANSMISSION LINE
TOWER GROUNDING LUG
DRAIN LOOP
TOWER GUY STRAP
LAUNCHING UNIT
LAUNCHING UNIT
10 FT RF CABLE TO ANTENNA
15 FT RF CABLE TO RADIO SET
5 FT POWER CABLE
TAPE TO PREVENT WIND WHIP
SPRING
10 FT POWER CABLE
GUY WIRE
BASE OF TOWER
SNUBIT CLAMP
DE-ICING TRANSFORMER ASSEMBLY
TURNBUCKLE
GUY STAKE GP-112/G FOR FROZEN GROUND
ANCHOR SCREW
AC POWER CABLE
25 FT POWER CABLE
TM689-518

Figure 73. Surface-wave transmission line assembly, typical installation.

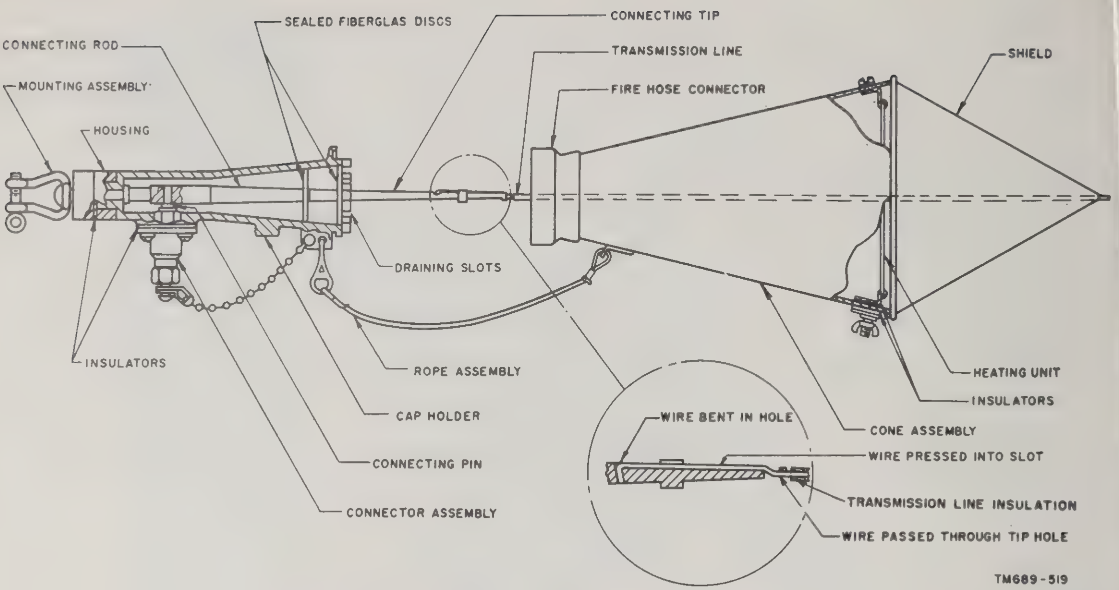

SEALED FIBERGLAS DISCS
CONNECTING TIP
CONNECTING ROD
TRANSMISSION LINE
SHIELD
MOUNTING ASSEMBLY
FIRE HOSE CONNECTOR
HOUSING
DRAINING SLOTS
INSULATORS
ROPE ASSEMBLY
HEATING UNIT
INSULATORS
CAP HOLDER
WIRE BENT IN HOLE
CONE ASSEMBLY
WIRE PRESSED INTO SLOT
CONNECTING PIN
TRANSMISSION LINE INSULATION
CONNECTOR ASSEMBLY
WIRE PASSED THROUGH TIP HOLE
TM689-519

Figure 74. Launching unit, cutaway view.

of the tensioning spring in the guy assembly; lock the snubit clamp.

s. Close the turnbuckle until the transmission line wire is stretched taut enough to remove the waves in the wire. Proper tightness is reached when further tightening does not pull the spring assembly eyebolt any further from the spring case. The transmission line copper wire is stretching slightly at this point.

t. Attach the 10-foot length of power cable to the launching unit and tape it to the spring assembly to prevent wind whipping (fig. 76).

u. Unscrew the cap on the coaxial connector assembly mounted on the housing and screw it tightly on the cap holder threads (fig. 74). This prevents the swinging chain from shorting out the de-icing current to ground through the grounded coaxial transmission line.

v. Connect one end of the 15-foot rf cable assembly to the coaxial receptacle on the launching unit housing and the other end to the radio set. Tape the rf connector with a good grade of electrical tape (rubber or plastic) to seal the connector from dirt and moisture and to prevent vibration from loosening the connector.

w. Connect one end of the 25-foot power cable assembly to the nearest grounding lug on Tower AB–216/U or to a suitable point on other towers; follow the method given in *e* above. Connect the other end to the lowest voltage terminal, marked *10 VOLTS,* of the de-icing transformer assembly.

x. Connect one end of the 10-foot power cable assembly to the terminal at the large end of the bottom launching unit cone and the other end to the common tap, marked *O-VOLTS COMMON,* on the de-icing transformer assembly.

y. Connect the 25-foot power cable assembly to the receptacle on the de-icing transformer assembly and plug it into a 115-volt 60-cps power source. The power source is an auxiliary equipment outlet on the back of Radio Set AN/TRC–29 transmitter rack when that equipment is in use.

z. Turn the ac line switch to ON and note the heating current on the ammeter. It should indicate between 40 and 60 amperes (red marks). If the current is low, turn off the transformer ac line switch and place the 25-foot tower cable on the next higher voltage tap. Repeat until a current reading between the red marks is obtained.

Caution: Do not leave the de-icing transformer assembly turned on if the air temperature is expected to rise above 80° F. during the day.

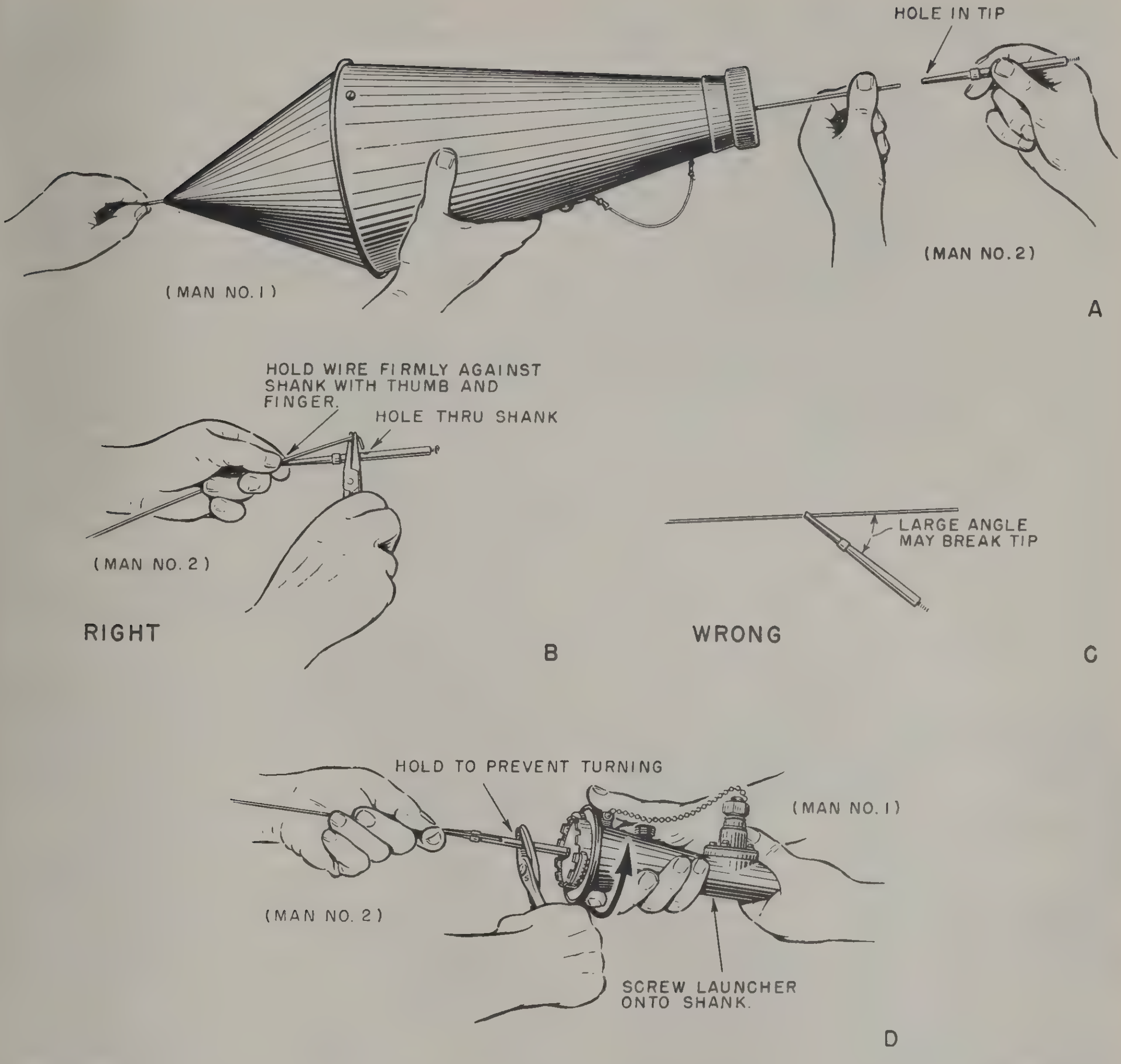

HOLE IN TIP
(MAN NO.1)
(MAN NO.2)
A
HOLD WIRE FIRMLY AGAINST SHANK WITH THUMB AND FINGER.
HOLE THRU SHANK
(MAN NO. 2)
RIGHT
B
LARGE ANGLE MAY BREAK TIP
WRONG
C
HOLD TO PREVENT TURNING
(MAN NO. 1)
(MAN NO. 2)
SCREW LAUNCHER ONTO SHANK.
D
TM689-522

Figure 75. Proper installation of tip.

51. Installation of Klystron, Crystals, and Duplexer

a. General. The transmitter klystron, transmitter and receiver crystals, and duplexer are shipped separately (or inside one of the spare parts boxes). Note that the equipment is shipped with a dummy klystron to prevent damage. Only one set consisting of klystrons, crystals, and duplexer is provided at a terminal, and only two sets at a repeater; a group is not provided for the spare set. Extra klystrons and crystals are provided in each group and these should be inserted in the spare set. However, only one duplexer is provided for each group; therefore, one is not normally available for installation on the spare set.

b. Installation of Transmitter Klystron. To install the transmitter klystron in the radio transmitter, proceed as follows:

(1) Examine the new klystron to be sure the cavity plates are approximately parallel. If necessary, turn either of

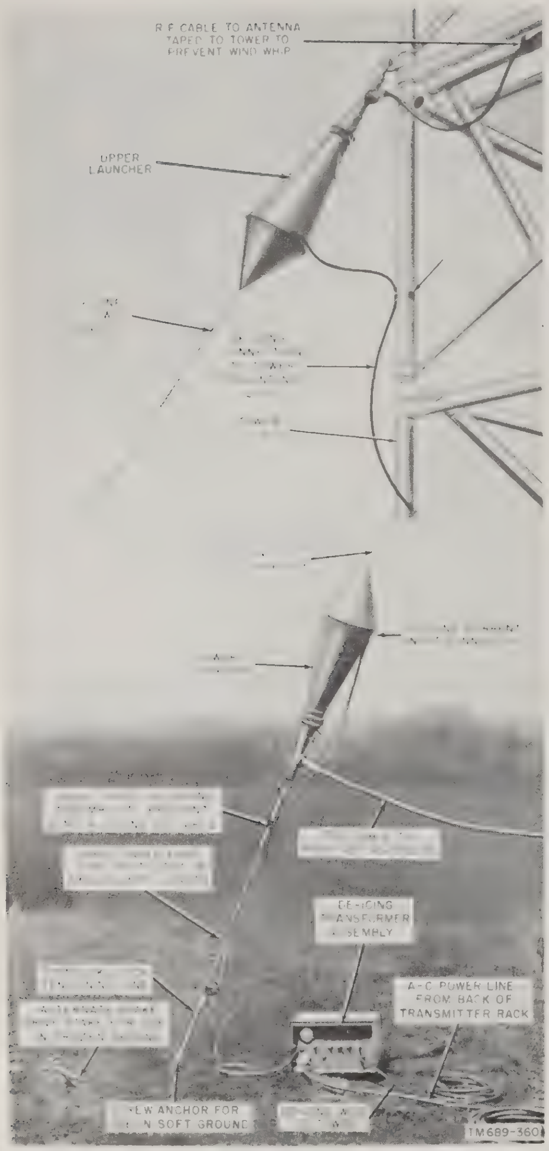

R F CABLE TO ANTENNA TAPED TO TOWER TO PREVENT WIND WHIP
UPPER LAUNCHER
DE-ICING TRANSFORMER ASSEMBLY
A-C POWER LINE FROM BACK OF TRANSMITTER RACK
EW ANCHOR FOR N SOFT GROUND
TM689-360

Figure 76. Launcher connection to tower.

the two tuning screws or the long fine tuning screw (fig. 92) as required to parallel the plates.

(2) Remove the radio transmitter protective back cover by turning the six Dzus fasteners on the cover about ½ turn counterclockwise.

(3) Remove the dummy klystron.

(4) Carefully put the klystron into position (fig. 77) *without forcing*. It may be necessary to loosen the clutch on the motor drive (fig. 78) and turn the fine tuning screw a fraction of a turn so that it will readily slip into the afc motor coupling.

(5) From the rear, fasten the klystron mount securely by turning the three wingnuts (one on extension shaft available from rear of transmitter) clockwise until they are fingertight (fig. 77).

(6) Connect the grounding strap to the klystron output connector.

(7) Connect the octal base on the klystron.

(8) Connect the rf cable to the klystron output; be sure the connection is fingertight. Tighten the grounding strap by turning the thumbscrew clockwise.

(9) Replace the back cover and snap the six Dzus fasteners closed.

(10) From the front of the radio transmitter, connect the reflector connector cap on klystron.

c. Insertion of Transmitter Crystal. Determine the transmitter crystal frequency required to operate on the desired channel frequency (par. 39*g*). Select a crystal with this channel marking and insert it in the crystal socket on the front of the radio transmitter (fig. 78).

d. Insertion of Receiver Crystal. Determine the receiver crystal frequency required to operate on the desired channel (par. 39*g*). Select a crystal with this channel marking and insert it in the crystal socket on the front of the radio receiver (lower right hand side, fig. 98).

e. Installation of Duplexer. The duplexer is mounted on the back of the radio receiver and held in place by turning the four Dzus fasteners clockwise (fig. 26). It can be mounted with either the channels 1–8 or channels 15–27 receptacle (for the CU–368/TRC–29 and equivalent receptacles for the CU–369/TRC–29) positioned over the TRANSMITTER CONNECTION on the radio transmitter rear frame. The way it is installed depends on the transmitter channel (fig. 25).

f. Insertion of Afc Chopper. The afc chopper is packed in the spare parts box. Insert it in its socket on the chopper amplifier subchassis (fig. 10).

g. Cable Troughs. To minimize wear and tear on the interconnecting cables, cable troughs

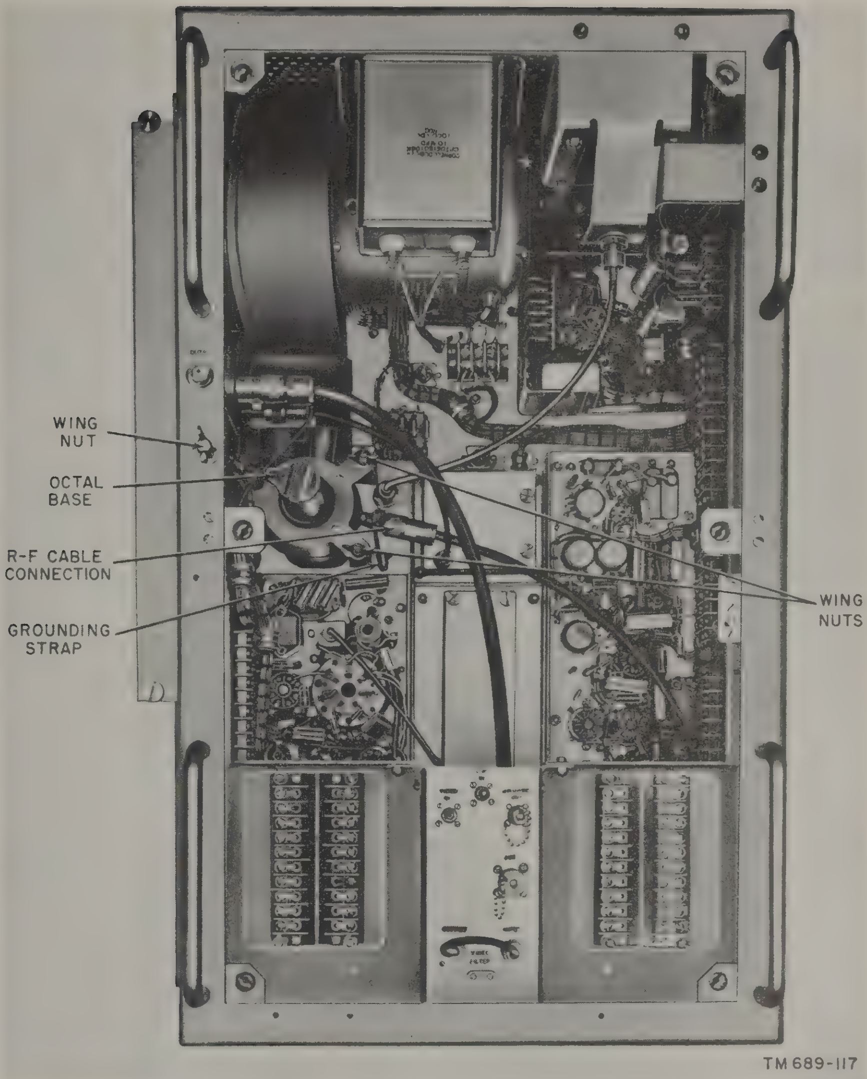

WING NUT
OCTAL BASE
R-F CABLE CONNECTION
GROUNDING STRAP
WING NUTS
TM 689-117

Figure 77. Location of klystron mounting elements on rear of transmitter.

about 3 inches wide and 4 inches deep should be installed between equipments (figs. 56 through 59).

52. Service Upon Receipt of Used or Reconditioned Equipment

a. Follow the instructions given in paragraph 47 for uncrating, unpacking, and checking the equipment.

b. Check the used or reconditioned equipment for tags or other indications pertaining to changes in wiring of the equipment. If any changes in wiring have been made, note the change in this manual, preferably on the schematic diagram.

c. Perform the installation and connection procedures given in this and the following sections.

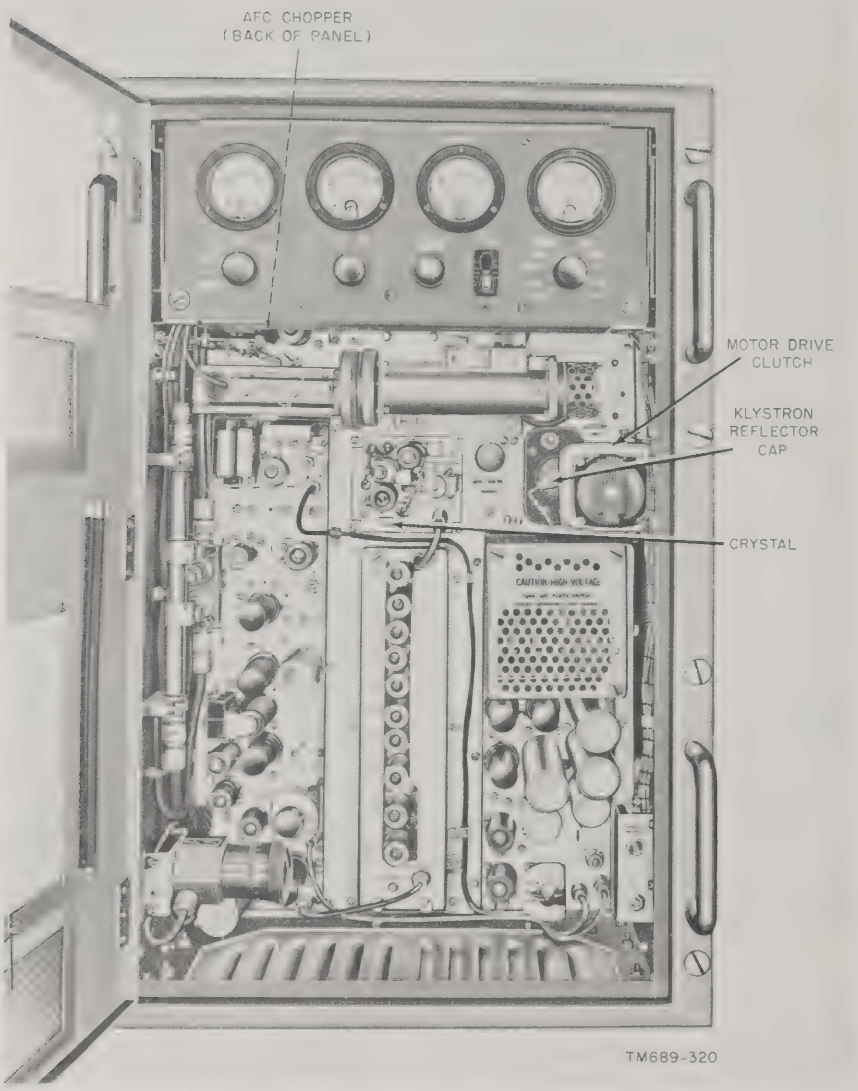

AFC CHOPPER
(BACK OF PANEL)
MOTOR DRIVE
CLUTCH
KLYSTRON
REFLECTOR
CAP
CRYSTAL
CAUTION HIGH VOLTAGE
TM689-320

Figure 78. Radio transmitter, showing klystron and transmitter crystal in place, front view.

Section III. CONNECTION OF RADIO SET AN/TRC–29

53. Introduction

All interconnections are factory-made between components within the transmitter and receiver rack before the equipment is shipped except for the CG–409C/U (1 ft 7 in.) and CG–409C/U (2 ft 6 in.) cables. Only connections between the transmitter and receiver racks, two radio sets at a repeater, or radio set and video equipment must be made. The procedures for making these connections are given in this section.

54. Location of Receptacles

Before connections are made, determine and locate all receptacles and the signal present at each (*a–e* below).

a. Transmitter Rack (fig. 79). The chart below lists the receptacles located at the rear of the transmitter rack and the signal present at each receptacle.

Receptacle	Component	Signal
TRANSFER CONTROL (J3)	Order-wire transmitter	Provides transfer control signals when switchover equipment is used.
ORDER WIRE INTERCONN (J1)	Order-wire transmitter	Audio and control signals from order-wire receiver are fed to this receptacle.
ORDER WIRE CARR OUTPUT (J2)	Order-wire transmitter	The fm order-wire carrier signal is obtained from this receptacle.
RF OUTPUT	Radio transmitter	Rf output signal.
VIDEO INPUT (J14)	Radio transmitter	The video signal applied to the modulator is fed to this receptacle.
OW CARR INPUT (J15)	Radio transmitter	The order-wire carrier signal is fed into this receptacle.
MON REC OUTPUT	Radio transmitter	A detected video signal obtained from the monitoring circuits available for test purposes.
RF TEST OUTPUT (J5)	Radio transmitter	Test rf output signal is obtained from this receptacle. The level of this signal varies for each set and will be between −65 and −71 db below the rf output level. The actual level obtained is marked on the receptacle.
OUTPUT	Radio transmitter	The output of the video filter is obtained at this receptacle which is permanently attached to a cable.
INPUT (J1)	Radio transmitter	The input to the video filter is fed to this receptacle.
XMTR POWER INTERCONN (J8)	High-voltage power supply	Power supply voltages to and from the low-voltage power supply are fed through this receptacle.
UTILITY POWER (J4 to J7)	High-voltage power supply	115 volts ac, convenience outlets.
REC 115VAC (J2)	High-voltage power supply	Primary power for the receiving equipment is fed from this receptacle.
AUX 115VAC (J3)	High-voltage power supply	Auxiliary 115 volts ac, power output.
AC POWER INPUT (J1)	High-voltage power supply	Primary power to the transmitter and receiver racks is applied through this receptacle.

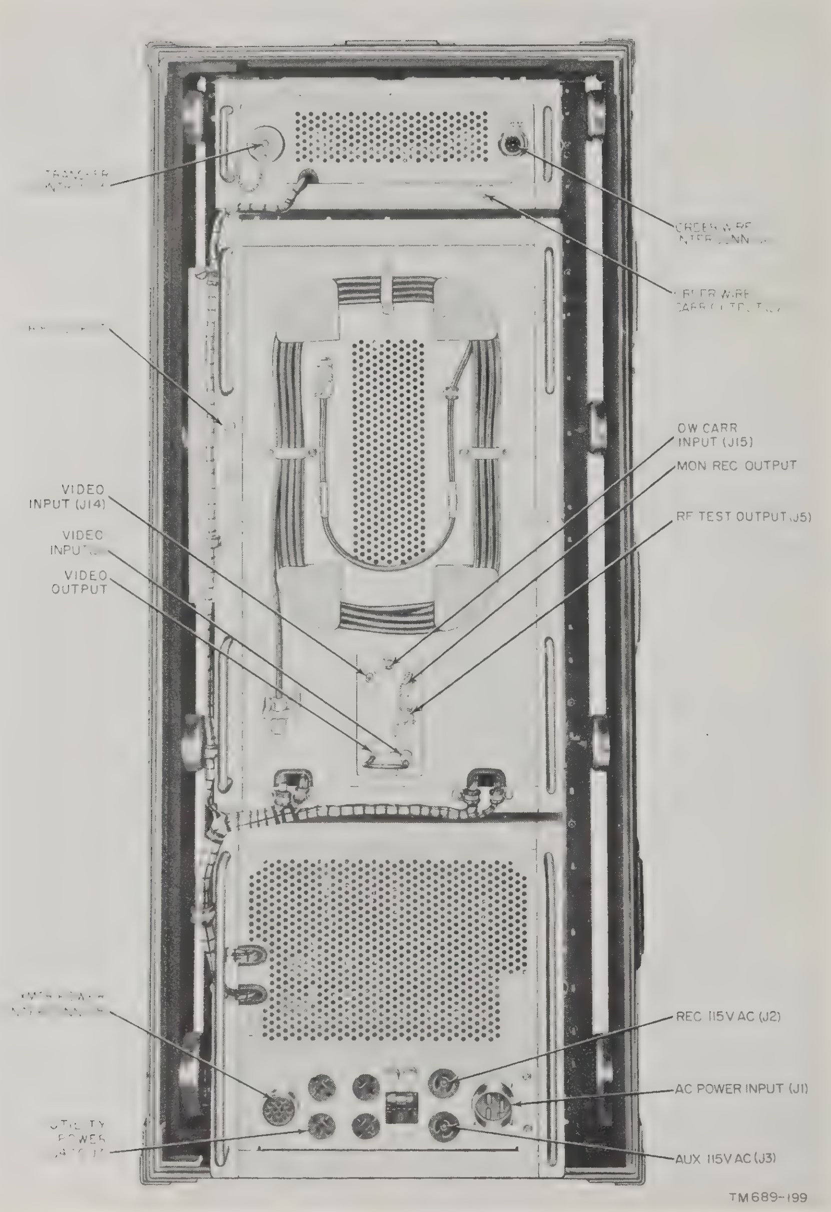

TRANSFER
ORDER WIRE INTER CONN
ORDER WIRE CARR OUTPUT
OW CARR INPUT (J15)
MON REC OUTPUT
VIDEO INPUT (J14)
RF TEST OUTPUT (J5)
VIDEO INPUT
VIDEO OUTPUT
REC 115V AC (J2)
AC POWER INPUT (J1)
UTILITY POWER
AUX 115V AC (J3)
TM689-199

Figure 79. Transmitter rack, rear view showing receptacles.

b. Receiver Rack (fig. 80). The chart below lists the receptacles located at the rear of the receiver rack and the signal present at each receptacle.

Receptacle	Component	Signal
OW CARR FILTER OUTPUT (J9)	Order-wire receiver	Video output of order-wire carrier filter is obtained at this receptacle.
DIV RELAY OUTPUT (J4)	Order-wire receiver	Video output obtained from contacts of diversity relay K1 obtained at this receptacle.
TRANSFER CONTROL (J5)	Order-wire receiver	Provides transfer control signals when switchover equipment is used.
VIDEO INPUT FROM REC (J1)	Order-wire receiver	Video signal obtained at output of radio receiver is fed to this receptacle.
VIDEO INPUT FROM DIV REC (J3)	Order-wire receiver	Video signal obtained at output of diversity radio receiver is fed to this receptacle.
VIDEO OUTPUT (J2)	Order-wire receiver	The receiving equipment video output signal is obtained at this receptacle.
REPEATER INTERCONN (J7)	Order-wire receiver	Transmission and reception of order-wire audio, ring, and alarm signals (between order-wire receivers at a repeater) are effected through this receptacle.
ORDER WIRE INTERCONN (J6)	Order-wire receiver	Audio and control signals for order-wire transmitter appear at this receptacle.
DIVERSITY INTERCONN (J8)	Order wire receiver	Interconnection between two receivers connected for diversity operation is provided through this receptacle.
REC (E7)	Order-wire receiver	For connection to remote handset.
XMTR (E8)	Order-wire receiver	For connection to remote handset.
RING (E9)	Order-wire receiver	For connection to remote handset.
GND (E10)	Order-wire receiver	For connection to remote handset.
RF INPUT (J1)	Radio receiver	Rf input to receiver.
ANTENNA ADAPTER (P1)	Radio receiver	Enables connection from antenna to rf input cable when duplexer is not used.
VIDEO OUTPUT MONITOR (J7)	Radio receiver	Video signal obtained at output of radio receiver is fed to this receptacle for monitoring purposes.
VIDEO OUTPUT TO ORDER WIRE REC (J6).	Radio receiver	Video signal obtained at output of radio receiver for application to order-wire receiver is obtained at this receptacle.
115V AC INPUT (J1)	Receiver power supply	Primary power to the receiver rack is obtained at this receptacle.
XMTR PWR INTERCONN (J1)	Low-voltage power supply	Power supply voltages to and from transmitter rack are fed through this receptacle.

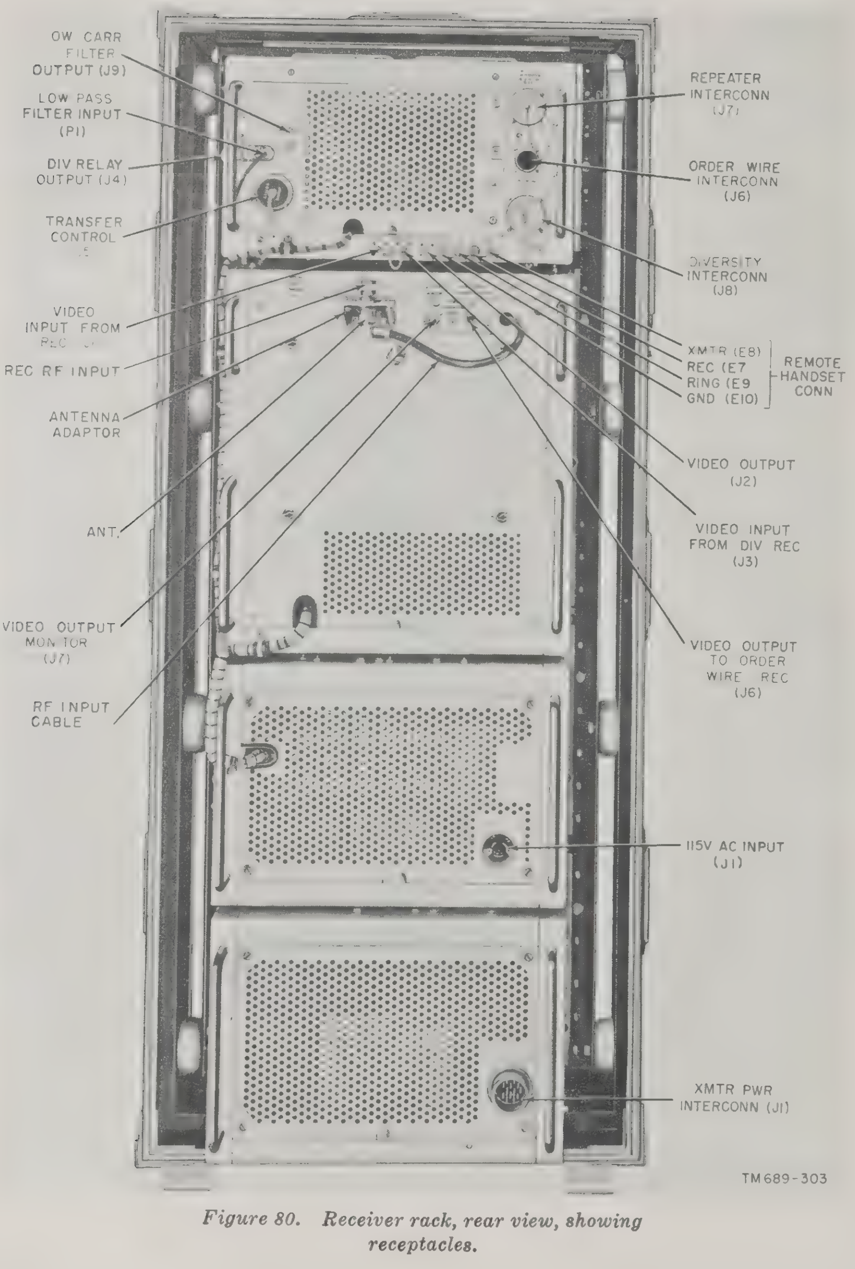

OW CARR FILTER OUTPUT (J9)
LOW PASS FILTER INPUT (P1)
DIV RELAY OUTPUT (J4)
TRANSFER CONTROL
VIDEO INPUT FROM REC
REC RF INPUT
ANTENNA ADAPTOR
ANT.
VIDEO OUTPUT MONITOR (J7)
RF INPUT CABLE
REPEATER INTERCONN (J7)
ORDER WIRE INTERCONN (J6)
DIVERSITY INTERCONN (J8)
XMTR (E8)
REC (E7
RING (E9
GND (E10)
REMOTE HANDSET CONN
VIDEO OUTPUT (J2)
VIDEO INPUT FROM DIV REC (J3)
VIDEO OUTPUT TO ORDER WIRE REC (J6)
115V AC INPUT (J1)
XMTR PWR INTERCONN (J1)
TM689-303

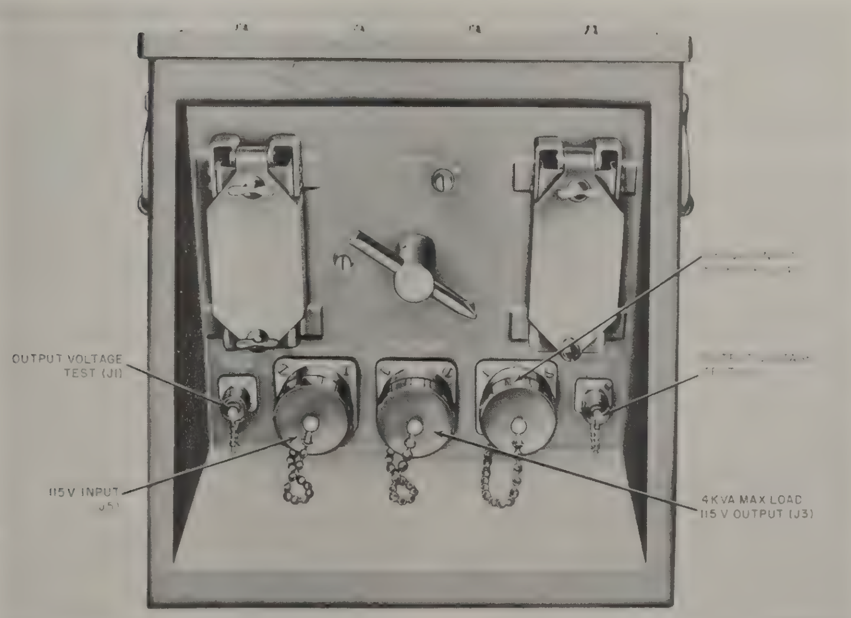
Figure 80. Receiver rack, rear view, showing receptacles.

c. Autotransformer (fig. 81). The chart below lists the receptacles located on the autotransformer and the signal present at each receptacle.

Receptacle	Signal
OUTPUT VOLTAGE TEST left and right hand side (J1 and J2).	The output voltage of the autotransformer is available across these two receptacles for test purposes.
115 V INPUT (J5)	This receptacle is used for primary power input when primary voltage is between 100 and 130 volts.
230 V INPUT (J4)	This receptacle is used for primary power input when primary voltage is between 200 and 260 volts.
4 KVA MAX. LOAD 115 V OUTPUT (J3).	The autotransformer output voltage is obtained from this receptacle.

d. Switchbox SA–357/G. The chart below lists the receptacles located on the switchbox and the signal present at each receptacle.

Receptacle	Signal
115/230 VAC OUTPUT right and left (J1 and J2).	These receptacles provide output voltage selected by the INPUT SELECTOR SWITCH.
115/230 VAC INPUT 1 (J3).	Primary power voltage source designated as No. 1 is connected to this receptacle.
115/230 VAC INPUT 2 (J4).	Primary power voltage source designated as No. 2 is connected to this receptacle.
GROUND	This post is connected to a ground stake or other suitable **ground** which is common to all equipment in station. For operator protection, all radio set and video equipment should use this common ground stake.



TM689-315

Figure 81. Autotransformer receptacles.

e. Handset-Signaling Unit H–102/TRC–29. This unit contains four posts marked RING (E1), REC (E2), XMTR (E3), and GND (E4) and a terminal board marked HANDSET CONN. (E5) with three terminals marked T, C, and R. These connect to similarly marked posts and terminals in the order-wire receiver.

f. Duplexers CU–368/TRC–29 and CU–369/TRC–29. The chart below lists the receptacles included on the duplexer and the signal present at each receptacle.

Receptacle	Duplexer	Signal
CHANNELS 1–8	CU–368/TRC–29	Accepts or feeds signals whose frequencies are in the low-pass band.
CHANNELS 1–14	CU–369/TRC–29	
CHANNELS 15–27	CU–368/TRC–29	Accepts or feeds signals whose frequencies are in the high-pass band.
CHANNELS 20–27	CU–369/TRC–29	
ANTENNA	Both	Accepts and feeds rf signals to and from antenna.

55. Primary Power Connections

Connect the primary power for each radio set as follows:

a. Place the autotransformer within 10 feet of the primary power source so that the 15-foot cable can be used. If possible, locate the autotransformer near the transmitter rack.

b. Connect Electrical Power Cable Assembly CX–2442/U (10 ft) between the primary power source and the 230-V INPUT receptacle on the autotransformer when the primary source voltage is between 200 and 260 volts, or the 115-V INPUT receptacle when the primary voltage source is between 100 and 130 volts. Be sure the latches that cover the circuit breakers are closed (fig. 81).

c. Place the switchbox within 15 feet of the autotransformer. It should also be within 150 feet of the transmitter rack.

d. Connect cable CX–2440/U (15 ft) between the 4 KVA MAX. LOAD 115-V OUTPUT receptacle on the autotransformer and the 115/230 VAC INPUT 2 receptacle in the switchbox.

e. Place the INPUT SELECTOR SWITCH in the 2 position.

f. Connect the 115-volt, ac, alternate power source, when available, to 115/230 VAC INPUT 1 receptacle on the switchbox.

g. Connect cable CX–2440/U (150 ft) between the 115/230 VAC OUTPUT receptacle of the switchbox (either one) and the AC POWER INPUT receptacle in the high-voltage power supply.

h. Connect the lugged end of Electrical Lead CX–2683/U to the GROUND post of the switchbox and the tinned end to a suitable ground, such as Electrical Grounding Stake MX–148/G. This provides a common ground for all equipment located at any one station, including video equipment, to avoid the possibility of any voltage existing between equipment racks.

Note. Whenever possible, all power supply cables should be placed in cable troughs.

56. Interrack Connections

The following interrack connections are made on all radio sets.

a. Connect cable CG–409/U (2 ft 6 in.) between the ORDER WIRE CARR OUTPUT receptacle on the order-wire transmitter and the OW CARR INPUT receptacle on the radio transmitter.

b. Connect cables CG–409C/U (1 ft 7 in.) between the VIDEO INPUT FROM REC receptacle on the order-wire receiver to the VIDEO OUTPUT TO ORDER WIRE REC receptacle on the radio receiver.

57. Radio Set AN/TRC–29 Interrack Connections

a. The following interrack connections are made on all radio sets:

(1) Connect cable CX–2445/U (10 ft) between the XMTR POWER INTERCONN receptacle on the high-voltage power supply and the XMTR POWER INTERCONN receptacle on the low-voltage power supply.

(2) Connect cable CX–2441/U (10 ft) between the REC 115 VAC receptacle on the high-voltage power supply and the 115 VAC INPUT receptacle on the receiver power supply.

b. Whenever possible, these cables should be placed in cable troughs.

58. Duplexer Connections

The following connections are made on all duplexers:

Note. Duplexers are mounted only on operating sets.

a. Connect cable CG–1182/U (3 ft 2 in.) between the RF OUTPUT receptacle on the radio transmitter and the receptacle of the duplexer over the TRANSMITTER CONNECTION marking on the radio receiver rear frame.

b. Connect the cable (attached to the ground launcher) that is associated with the radio set involved to the ANTENNA receptacle on the duplexer.

c. Connect the receiver RF INPUT cable to the receptacle over the RECEIVER CONNECTION marking on the radio receiver.

59. Terminal Connections

(fig. 82)

a. All the connections indicated in paragraphs 54, 55, and 56 are made on both the operating and spare sets. Connection to the duplexer is made on the operating set only. The following additional connections are made only on the operating set:

(1) Connect cable CG–409C/U (25 ft) between the VIDEO FILTER INPUT receptacle on the radio transmitter and the video output receptacle on the video equipment. Refer to the instruction manual on the video equipment involved for panel marking of this receptacle.

(2) Connect cable CG–409C/U (25 ft) between the VIDEO OUTPUT receptacle on the order-wire receiver and the video input receptacle on the video equipment. Refer to the instruction manual on video equipment involved for the panel marking of this receptacle.

b. Whenever possible, these cables should be placed within cable troughs.

c. On both operating and spare sets, make the following connections:

(1) Connect the VIDEO FILTER OUTPUT cable on the radio transmitter to the VIDEO INPUT receptacle directly above it.

(2) Connect the LOW PASS FILTER INPUT cable on the order-wire receiver to the OW CARR FILTER OUTPUT receptacle.

(3) Connect cable CX–2443/U (25 ft) through a cable trough, between the ORDER WIRE INTERCONN receptacle on the order-wire receiver and the ORDER WIRE INTERCONN receptacle on the order-wire transmitter.

d. On the spare radio set, perform the following:

(1) Connect cable CG–409C/U (25 ft) to the VIDEO FILTER INPUT receptacle on the radio transmitter. Run the cable through the cable trough and place the open end so that it can connect to the video output receptacle on the video equipment.

(2) Connect cable CG–409C/U (25 ft) to the VIDEO OUTPUT receptacle on the order-wire receiver. Run the cable through the trough and place the open end so that it can connect to the video input receptable on the video equipment.

60. Through Repeater Connections

(fig. 83)

a. All the connections indicated in paragraphs 54, 55, and 56 are made on both the operating and spare sets. The following additional connections are made only on the operating sets:

(1) Cable CX–2443/U (25 ft) between the REPEATER INTERCONN receptacle in the east-west order-wire receiver and the REPEATER INTERCONN receptacle in the west-east order-wire receiver, through a cable trough.

(2) Connect cable CX–2443/U (25 ft) between the ORDER WIRE INTERCONN receptacle in the east-west order-wire receiver and the ORDER WIRE INTERCONN receptacle in the east-west order-wire transmitter, through a cable trough.

(3) Connect cable CX–2443/U (25 ft) between the ORDER WIRE INTERCONN receptacle in the west-east order-wire receiver and the ORDER WIRE INTERCONN receptacle in the west-east order-wire transmitter, through a cable trough.

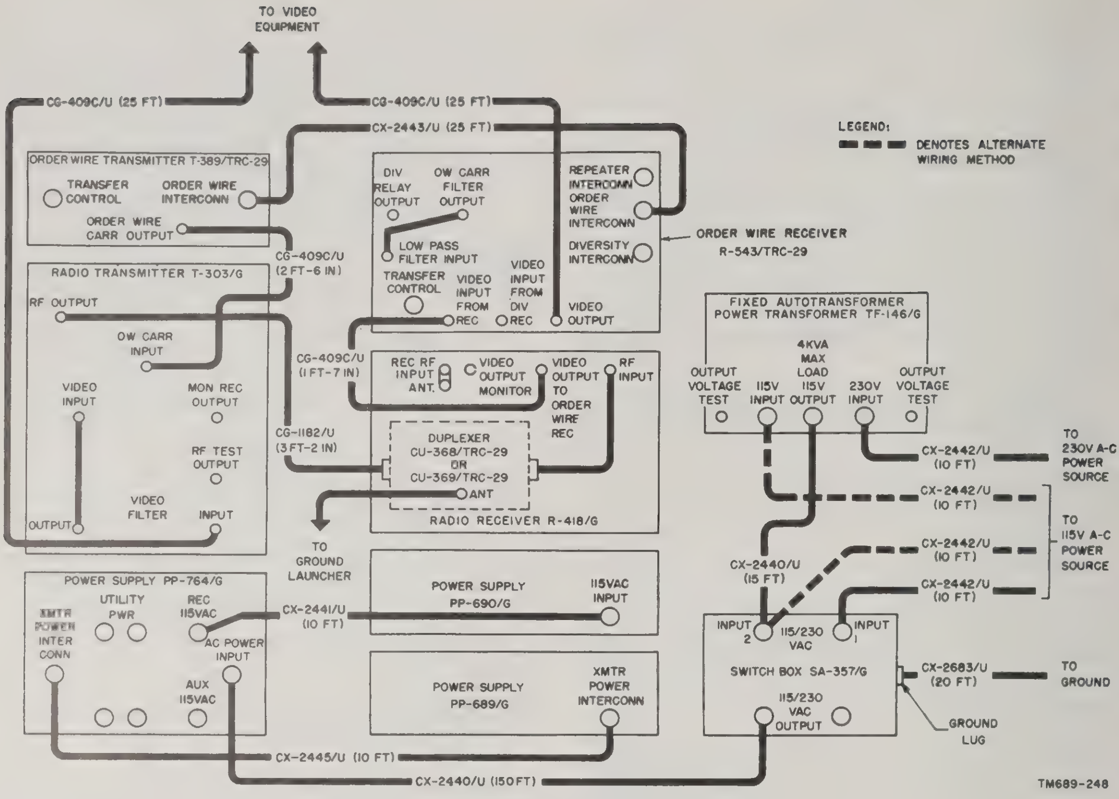

TO VIDEO EQUIPMENT
CG-409C/U (25 FT)
CG-409C/U (25 FT)
CX-2443/U (25 FT)
LEGEND:
DENOTES ALTERNATE WIRING METHOD
ORDER WIRE TRANSMITTER T-389/TRC-29
TRANSFER CONTROL
ORDER WIRE INTERCONN
ORDER WIRE CARR OUTPUT
DIV RELAY OUTPUT
OW CARR FILTER OUTPUT
LOW PASS FILTER INPUT
TRANSFER CONTROL
VIDEO INPUT FROM REC
VIDEO INPUT FROM DIV REC
VIDEO OUTPUT
REPEATER INTERCONN
ORDER WIRE INTERCONN
DIVERSITY INTERCONN
ORDER WIRE RECEIVER R-543/TRC-29
CG-409C/U (2 FT-6 IN)
RADIO TRANSMITTER T-303/G
RF OUTPUT
OW CARR INPUT
VIDEO INPUT
MON REC OUTPUT
RF TEST OUTPUT
VIDEO FILTER
INPUT
OUTPUT
CG-409C/U (1 FT-7 IN)
CG-1182/U (3 FT-2 IN)
REC RF INPUT
ANT.
VIDEO OUTPUT MONITOR
VIDEO OUTPUT TO ORDER WIRE REC
RF INPUT
DUPLEXER CU-368/TRC-29 OR CU-369/TRC-29
ANT
RADIO RECEIVER R-418/G
TO GROUND LAUNCHER
FIXED AUTOTRANSFORMER POWER TRANSFORMER TF-146/G
OUTPUT VOLTAGE TEST
115V INPUT
4KVA MAX LOAD 115V OUTPUT
230V INPUT
OUTPUT VOLTAGE TEST
CX-2442/U (10 FT)
TO 230V A-C POWER SOURCE
CX-2442/U (10 FT)
CX-2442/U (10 FT)
CX-2442/U (10 FT)
TO 115V A-C POWER SOURCE
CX-2440/U (15 FT)
POWER SUPPLY PP-764/G
XMTR POWER INTER CONN
UTILITY PWR
REC 115VAC
AC POWER INPUT
AUX 115VAC
CX-2441/U (10 FT)
POWER SUPPLY PP-690/G
115VAC INPUT
POWER SUPPLY PP-689/G
XMTR POWER INTERCONN
INPUT 2
115/230 VAC
INPUT 1
SWITCH BOX SA-357/G
115/230 VAC OUTPUT
CX-2683/U (20 FT)
TO GROUND
GROUND LUG
CX-2445/U (10 FT)
CX-2440/U (150FT)
TM689-248

Figure 82. Operating radio set at a terminal, interconnection diagram.

(4) Connect cable CG–409C/U (25 ft) between the VIDEO INPUT receptacle on the east-west radio transmitter and the VIDEO OUTPUT receptacle on the east-west order-wire receiver.

(5) Connect cable CG–409C/U (25 ft) between the VIDEO INPUT receptacle on the west-east radio transmitter and the VIDEO OUTPUT receptacle on the west-east order-wire receiver.

b. On both operating and spare sets, make the following connections:

(1) Connect the VIDEO FILTER OUTPUT cable on the radio transmitter to the VIDEO FILTER INPUT receptacle.

(2) Connect the LOW PASS FILTER INPUT cable on the order-wire receiver to the OW CARR FILTER OUTPUT receptacle.

c. On the spare set, make the following connections:

(1) Connect cable CX–2443/U (25 ft) to the ORDER WIRE INTERCONN connection on the order-wire transmitter and store the cable in a convenient location so that the open end can be connected to the ORDER WIRE INTERCONN receptacle of either the east-west or west-east order-wire receiver.

(2) Connect cable CX–2444/U (25 ft) to the REPEATER INTERCONN receptacle and store the cable in a convenient location so that the open end can be connected to the REPEATER INTERCONN receptacle of either the east-west or west-east order-wire receiver.

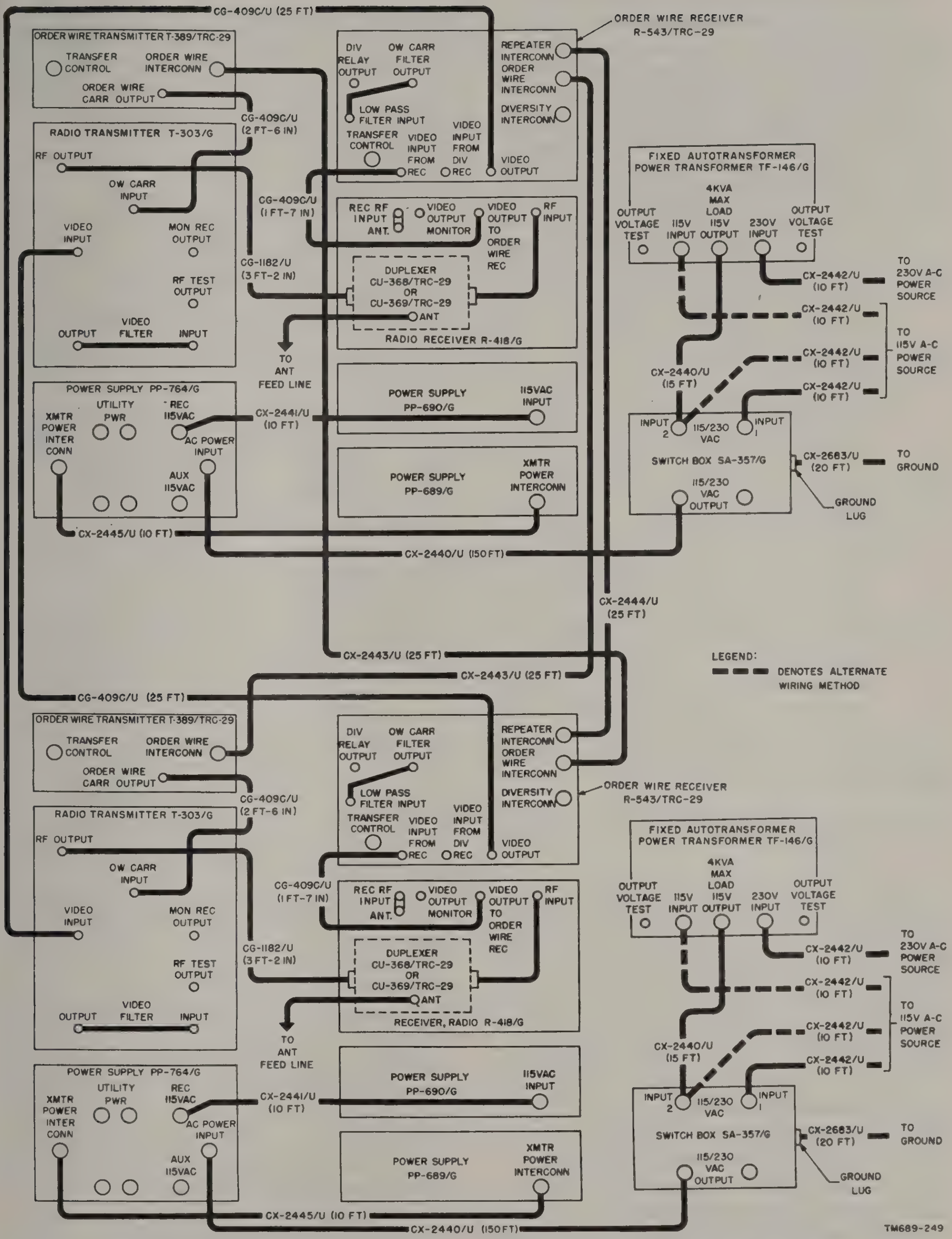

CG-409C/U (25 FT)
ORDER WIRE TRANSMITTER T-389/TRC-29
TRANSFER CONTROL
ORDER WIRE INTERCONN
ORDER WIRE CARR OUTPUT
CG-409C/U (2 FT-6 IN)
RADIO TRANSMITTER T-303/G
RF OUTPUT
OW CARR INPUT
VIDEO INPUT
MON REC OUTPUT
RF TEST OUTPUT
OUTPUT
VIDEO FILTER
INPUT
CG-409C/U (1 FT-7 IN)
CG-1182/U (3 FT-2 IN)
DIV RELAY OUTPUT
OW CARR FILTER OUTPUT
LOW PASS FILTER INPUT
TRANSFER CONTROL
VIDEO INPUT FROM REC
VIDEO INPUT FROM DIV REC
VIDEO OUTPUT
REPEATER INTERCONN
ORDER WIRE INTERCONN
DIVERSITY INTERCONN
ORDER WIRE RECEIVER R-543/TRC-29
REC RF INPUT ANT.
VIDEO OUTPUT MONITOR
VIDEO OUTPUT TO ORDER WIRE REC
RF INPUT
DUPLEXER CU-368/TRC-29 OR CU-369/TRC-29
ANT
RADIO RECEIVER R-418/G
TO ANT FEED LINE
POWER SUPPLY PP-764/G
XMTR POWER INTER CONN
UTILITY PWR
REC 115VAC
AC POWER INPUT
AUX 115VAC
CX-2441/U (10 FT)
POWER SUPPLY PP-690/G
115VAC INPUT
POWER SUPPLY PP-689/G
XMTR POWER INTERCONN
CX-2445/U (10 FT)
CX-2440/U (150 FT)
FIXED AUTOTRANSFORMER POWER TRANSFORMER TF-146/G
4KVA MAX LOAD
OUTPUT VOLTAGE TEST
115V INPUT
115V OUTPUT
230V INPUT
OUTPUT VOLTAGE TEST
CX-2442/U (10 FT)
TO 230V A-C POWER SOURCE
CX-2442/U (10 FT)
CX-2442/U (10 FT)
TO 115V A-C POWER SOURCE
CX-2440/U (15 FT)
CX-2442/U (10 FT)
INPUT 2
115/230 VAC
INPUT 1
SWITCH BOX SA-357/G
CX-2683/U (20 FT)
TO GROUND
115/230 VAC OUTPUT
GROUND LUG
CX-2444/U (25 FT)
CX-2443/U (25 FT)
CX-2443/U (25 FT)
LEGEND:
DENOTES ALTERNATE WIRING METHOD
CG-409C/U (25 FT)
ORDER WIRE TRANSMITTER T-389/TRC-29
TRANSFER CONTROL
ORDER WIRE INTERCONN
ORDER WIRE CARR OUTPUT
CG-409C/U (2 FT-6 IN)
RADIO TRANSMITTER T-303/G
RF OUTPUT
OW CARR INPUT
VIDEO INPUT
MON REC OUTPUT
RF TEST OUTPUT
OUTPUT
VIDEO FILTER
INPUT
DIV RELAY OUTPUT
OW CARR FILTER OUTPUT
LOW PASS FILTER INPUT
TRANSFER CONTROL
VIDEO INPUT FROM REC
VIDEO INPUT FROM DIV REC
VIDEO OUTPUT
REPEATER INTERCONN
ORDER WIRE INTERCONN
DIVERSITY INTERCONN
ORDER WIRE RECEIVER R-543/TRC-29
CG-409C/U (1 FT-7 IN)
REC RF INPUT ANT.
VIDEO OUTPUT MONITOR
VIDEO OUTPUT TO ORDER WIRE REC
RF INPUT
CG-1182/U (3 FT-2 IN)
DUPLEXER CU-368/TRC-29 OR CU-369/TRC-29
ANT
RECEIVER, RADIO R-418/G
TO ANT FEED LINE
FIXED AUTOTRANSFORMER POWER TRANSFORMER TF-146/G
4KVA MAX LOAD
OUTPUT VOLTAGE TEST
115V INPUT
115V OUTPUT
230V INPUT
OUTPUT VOLTAGE TEST
CX-2442/U (10 FT)
TO 230V A-C POWER SOURCE
CX-2442/U (10 FT)
CX-2442/U (10 FT)
TO 115V A-C POWER SOURCE
CX-2440/U (15 FT)
CX-2442/U (10 FT)
POWER SUPPLY PP-764/G
XMTR POWER INTER CONN
UTILITY PWR
REC 115VAC
AC POWER INPUT
AUX 115VAC
CX-2441/U (10 FT)
POWER SUPPLY PP-690/G
115VAC INPUT
POWER SUPPLY PP-689/G
XMTR POWER INTERCONN
INPUT 2
115/230 VAC
INPUT 1
SWITCH BOX SA-357/G
CX-2683/U (20 FT)
TO GROUND
115/230 VAC OUTPUT
GROUND LUG
CX-2445/U (10 FT)
CX-2440/U (150 FT)
TM689-249

Figure 83. Operating radio sets in a through repeater station, interconnection diagram.

61. Drop-Channel Repeater Connections

a. All the connections indicated in paragraph 59 should be made for drop-channel repeater stations. Make the video signal connections to the drop-channel equipment as indicated in (1) through (4) below. Refer to the manual on drop-channel equipment for panel markings.

(1) Connect cable CG–409C/U (25 ft) between the VIDEO INPUT receptacle on the east-west radio transmitter and the video output receptacle of the east-west drop-channel equipment. The drop-channel equipment may include a CG–409C/U (25 ft) cable for this purpose; therefore, an extra cable may be available for use as a spare.

(2) Connect cable CG–409C/U (25 ft) between the VIDEO OUTPUT receptacle on the east-west order-wire receiver and the video input receptacle of the east-west drop-channel equipment.

(3) Connect cable CG–409C/U (25 ft) between the VIDEO INPUT receptacle on the west-east radio transmitter and the video output receptacle of the west-east drop-channel equipment.

(4) Connect cable CG–409C/U (25 ft) between the VIDEO OUTPUT receptacle on the west-east order-wire receiver and the video input receptacle of the west-east drop-channel equipment.

b. Whenever possible these cables should be placed within cable troughs.

62. Connection of Receivers for Diversity Operation

(fig. 84)

a. In diversity operation, the receiving portion of the spare radio set is used as the standby receiver. The preferred receiver is the receiving portion of an operating radio set. To avoid confusion, one receiver is arbitrarily designated as the preferred receiver and the other as the standby receiver. The principal difference between them functionally is that the preferred receiver is selected to monitor the control and switching functions for diversity operation. Connect the *operating* (preferred) radio set in the manner described in paragraph 59 for terminal station, paragraph 60 for through repeater stations, and paragraph 61 for drop-channel repeater stations. (Do *not* connect the *spare* (standby) radio set in the manner indicated in the above-mentioned paragraphs.) Disconnect the LOW PASS FILTER INPUT cable from the OW CARR FILTER OUTPUT receptacle and connect it to the DIV RELAY OUTPUT receptacle.

b. Connect the standby receiver in the following manner:

(1) Connect the plug with the red marking of cable CX–2684/U (15 ft) to the DIVERSITY INTERCONN receptacle on the preferred order-wire receiver. Connect the other end of this cable to the DIVERSITY INTERCONN receptacle on the standby receiver.

(2) Connect cable CG–409C/U (5 ft 1 in.) between VIDEO INPUT FROM DIV REC receptacle on the preferred order-wire receiver and the OW CARR FILTER OUTPUT receptacle on the standby order-wire receiver.

(3) Connect the LOW PASS FILTER INPUT cable to the DIV RELAY OUTPUT receptacle on the standby order-wire receiver.

(4) Connect cable CX–2441/U (10 ft) between the 115 VAC receptacle on the standby receiver power supply and the 115 VAC receptacle on its associated transmitter high-voltage power supply.

(5) Connect the cable attached to the ground launcher of the diversity antenna surface-wave transmission to the ANT. receptacle on the ANTENNA ADAPTER of the standby radio receiver.

(6) Connect the standby radio receiver rf input cable to the REC RF INPUT receptacle.

63. Operation Without Duplexer

The connections described in the previous paragraphs can be made on radio sets when not using a duplexer with the exception of the duplexer connection instructions given in paragraph 58. To operate without a duplexer, the following antenna connections must be made.

a. Connect the cable attached to the transmitting antenna ground launcher to the RF OUTPUT receptacle on the radio transmitter.

b. Connect the cable attached to the receiving

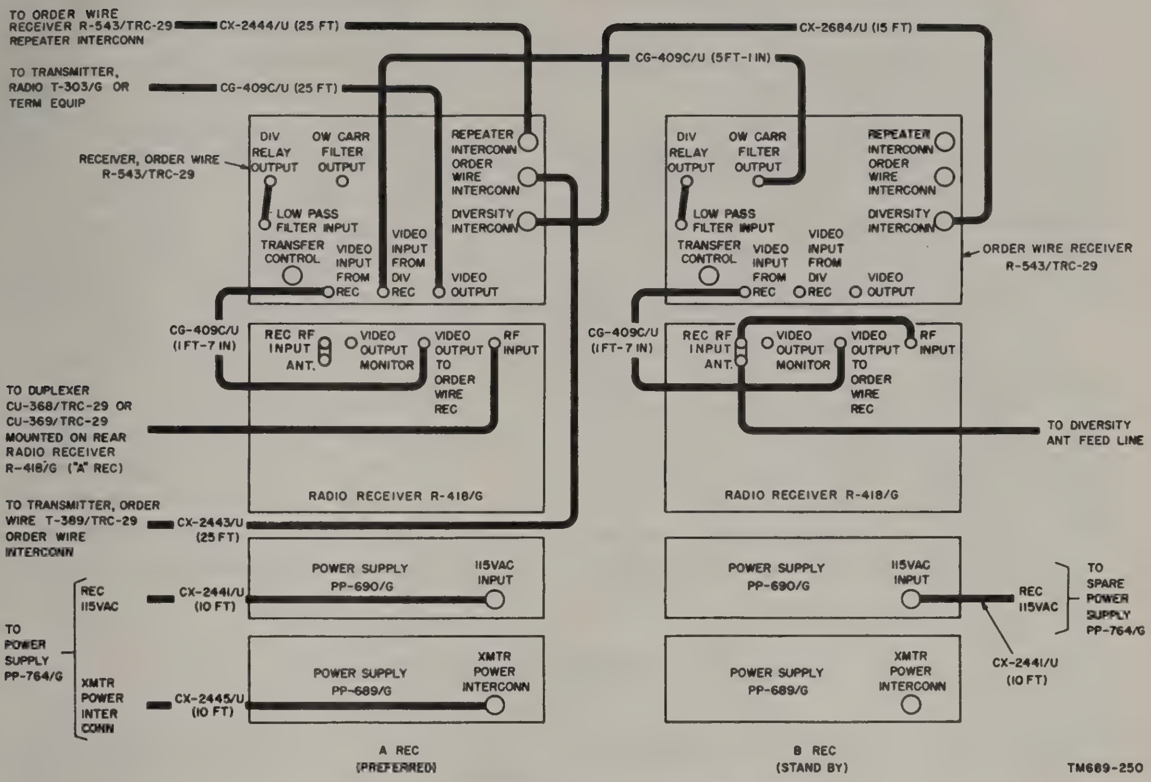

TO ORDER WIRE RECEIVER R-543/TRC-29 REPEATER INTERCONN
CX-2444/U (25 FT)
TO TRANSMITTER, RADIO T-303/G OR TERM EQUIP
CG-409C/U (25 FT)
CX-2684/U (15 FT)
CG-409C/U (5FT-1 IN)
RECEIVER, ORDER WIRE R-543/TRC-29
DIV RELAY OUTPUT
OW CARR FILTER OUTPUT
REPEATER INTERCONN
ORDER WIRE INTERCONN
LOW PASS FILTER INPUT
DIVERSITY INTERCONN
TRANSFER CONTROL
VIDEO INPUT FROM REC
VIDEO INPUT FROM DIV REC
VIDEO OUTPUT
ORDER WIRE RECEIVER R-543/TRC-29
CG-409C/U (1 FT-7 IN)
REC RF INPUT ANT.
VIDEO OUTPUT MONITOR
VIDEO OUTPUT TO ORDER WIRE REC
RF INPUT
TO DUPLEXER CU-368/TRC-29 OR CU-369/TRC-29 MOUNTED ON REAR RADIO RECEIVER R-418/G ("A" REC)
TO DIVERSITY ANT FEED LINE
RADIO RECEIVER R-418/G
TO TRANSMITTER, ORDER WIRE T-389/TRC-29 ORDER WIRE INTERCONN
CX-2443/U (25 FT)
POWER SUPPLY PP-690/G
115VAC INPUT
REC 115VAC
CX-2441/U (10 FT)
TO POWER SUPPLY PP-764/G
TO SPARE POWER SUPPLY PP-764/G
XMTR POWER INTER CONN
CX-2445/U (10 FT)
POWER SUPPLY PP-689/G
XMTR POWER INTERCONN
A REC (PREFERRED)
B REC (STAND BY)
TM689-250

Figure 84. Diversity operation, interconnection diagram.

antenna ground launcher to the ANT. receptacle on the back of the radio receiver.

c. Connect the radio receiver rf input cable to the RF INPUT receptacle.

64. Spare Set as Operating Equipment

a. General. The spare set normally available at each station can be used as an operating equipment in place of one of the *operating* sets. The connections required to effect this switchover are described in *b* through *e* below.

b. Switchover of Duplexer. When used, the duplexer on the *operating* set to be replaced must be removed and connected to the spare set. This is done in the following manner:

(1) Disconnect all the duplexer cables.
(2) Note the direction of the high pass filter arrow.
(3) Remove the duplexer by loosening four Dzus fasteners.
(4) Mount the duplexer on the spare set and lock it in place by tightening the Dzus fasteners. Be sure that the HIGH PASS arrow is pointing in the same direction as noted in (2) above.
(5) Connect the cables to the duplexer as described in paragraph 58.

c. Antenna Switchover When Duplexer is Not Used. When a duplexer is not used, disconnect all antenna connections from the set to be replaced. Connect these antenna cables to the spare set as described in paragraph 63.

d. Terminal Connections. At a terminal, the following additional transfers of connections are required:

(1) Disconnect the cable from the video equipment video output receptacle, and connect the spare set cable (connected at the other end to VIDEO FILTER INPUT receptacle) to this receptacle.
(2) Disconnect the cable from the video equipment video input receptacle, and connect the spare set cable (connected

at the other end to the VIDEO OUTPUT receptacle) to this receptacle.

(3) Transfer the cables from the failed unit to the spare unit.

e. Through Repeater Connections. At a repeater, the following additional cables must be transferred: the REPEATER INTERCONN, ORDER WIRE INTERCONN, and video signal cables.

(1) Connect cable CX–2444/U (25 ft) between the REPEATER INTERCONN receptacle in the east-west order-wire receiver and REPEATER INTERCONN receptacle in the west-east order-wire receiver.

(2) Connect cable CX–2443/U (25 ft) between the ORDER WIRE INTERCONN receptacle in the east-west order-wire receiver and the ORDER WIRE INTERCONN receptacle in the east-west order-wire transmitter.

(3) Connect cable CX–2443/U (25 ft) between the ORDER WIRE INTERCONN receptacle in the west-east order-wire receiver and the ORDER WIRE INTERCONN receptacle in the west-east order-wire transmitter.

(4) Connect cable CG–409C/U (25 ft) between the VIDEO INPUT receptacle on the east-west radio transmitter and the VIDEO OUTPUT receptacle on the east-west order-wire receiver.

(5) Connect cable CG–409C/U (25 ft) between the VIDEO INPUT receptacle on the west-east radio transmitter and the VIDEO OUTPUT receptacle on the west-east order-wire receiver.

Section IV. CONTROLS AND INSTRUMENTS

65. Order-Wire Transmitter T–389/TRC–29 (fig. 85)

The chart below lists the controls and instruments of the order-wire transmitter.

Control Front panel controls	Function These controls do not interrupt communications
Meter (M1) and meter switch (S2)	A five-position wafer switch that connects the meter to various circuits in the order-wire transmitter. Positions and functions are as follows: *Position* — *Function* CARR LIM GRID — Indicates relative level of 6-mc carrier from carrier oscillator V2. DISCR+ and DISCR− — Indicates frequency error (positive or negative) of 6-mc oscillator. AUDIO — With the ORDER-WIRE TEST **switch** (S1) in in the OPR position, indicates audio-modulation percentage of the 6-mc carrier. With S1 in the INPUT AUDIO position, indicates audio-modulation level. +140V — Indicates B+ voltage of order-wire transmitter.
TRANSFER CONTROL ON indicator lamp (I 1).	Lights when operation with switchover equipment is selected.

Control	Function
Controls behind front cover	These controls may cause traffic outage
FIL circuit breaker (CB2)	Applies order-wire transmitter filament voltage when in ON position. Protects filament circuit from overloads.
PLATE circuit breaker (CB1)	Applies order-wire transmitter plate voltage when in ON position. Protects plate circuit from overloads.
TRANSFER CONTROL-MANUAL OPERATE toggle switch (S4).	In TRANSFER CONTROL position, selects operation with switchover equipment. In MANUAL OPERATE position, selects operation independent of standby equipment.
ORDER WIRE TEST SWITCH (S1)	A five-position wafer switch which permits various alinement and adjustment procedures as follows: *Position* — *Function* AFC OFF — Disables afc operation to facilitate discriminator alinement. OPR — This is the switch position which permits normal operation of the order-wire transmitter. In addition, when in this position, the actual percent audio modulation of the 6-mc carrier is shown on meter M1 when meter switch S2 is in AUDIO position. INPUT AUDIO — Furnishes an indication of the input level of audio modulation on meter M1 when meter switch S2 is in AUDIO position. THRU TONE — Positions the output of tone oscillator V5 across AUDIO LEVEL THRU CHAN control R1. LOCAL TONE — Positions the output of tone oscillator V5 across AUDIO LEVEL LOCAL INPUT control R2.
AUDIO LEVEL THRU CHAN control (R1)	Adjusts audio level of an order-wire through signal; that is, an order-wire signal obtained from another station for retransmission. Normally, it is adjusted to provide unit gain on each station-to-station hop.
AUDIO LEVEL LOCAL INPUT control (R22).	Adjusts audio level of the order-wire audio signal obtained from the local or remote handsets at the station.
ORDER WIRE CARR LEVEL control (R16).	Adjusts order-wire carrier output level.
+140V ADJ control (R51)	Permits adjustment of order-wire transmitter +140-volt supply. Once set, this control should not be disturbed.
Controls for depot adjustments	Do not operate these controls. Improper adjustment may require depot calibration since special depot test equipment is required.
AUDIO METER SENS control (R24)	Permits calibration of meter M1. This control is preset and should not be disturbed.
FREQ ADJ control (L1)	Adjusts frequency of order-wire carrier oscillator V2.
MOD SENS ADJ control (L2)	Adjusts modulation sensitivity of order-wire carrier oscillator V2.

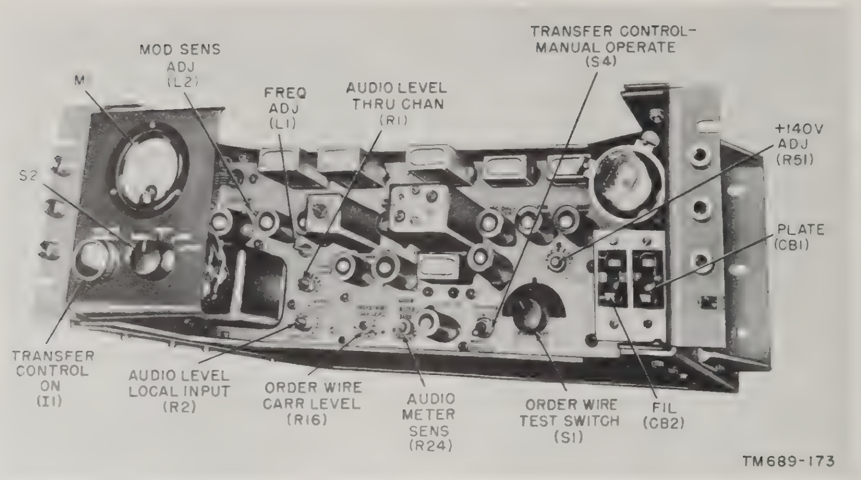

MOD SENS ADJ (L2)
M
S2
FREQ ADJ (L1)
AUDIO LEVEL THRU CHAN (R1)
TRANSFER CONTROL-MANUAL OPERATE (S4)
+140V ADJ (R51)
PLATE (CB1)
TRANSFER CONTROL ON (I1)
AUDIO LEVEL LOCAL INPUT (R2)
ORDER WIRE CARR LEVEL (R16)
AUDIO METER SENS (R24)
ORDER WIRE TEST SWITCH (S1)
FIL (CB2)
TM689-173

Figure 85. Order-wire transmitter controls.

66. Radio Transmitter T–303/G

(figs. 86 through 93)

The chart below lists the controls and instruments of the radio transmitter. Figures on which the controls can be found are indicated below each control.

Control	Function
METER A (M2) and meter switch (S4) (fig. 86).	A nine-position rotary switch that connects the meter to various circuits in the transmitter. The function of meter M2 and switch S4 is to permit monitoring of nine points in the radio transmitter to facilitate routine maintenance and provide a means for realinement and readjustment of the radio transmitter without using external meters. Positions and functions are as follows: *Position* — *Function* AFC 1ST MULT GRID ----- Indicates drive from crystal oscillator V11 to multiplier grid. AFC MIXER ---------------- Indicates drive from crystal multiplier chain. KLYSTRON POWER OUT -- Indicates relative power output of klystron oscillator V38. PA CATH CUR ------------- Indicates cathode current of power amplifier tube V37. 1ST LIM GRID ------------ Indicates level of if. voltage, applied to first limiter grid V19. AFC CORRECTION– and AFC CORRECTION+ — Indicate frequency error and polarity. REFL V ------------------ Indicates reflector voltage of klystron oscillator V38. BEAM V ------------------ Indicates beam voltage of klystron oscillator V38.
PEAK VTVM meter (M4) and meter switch (S5) (fig. 86).	A two-position rotary switch that determines whether meter reads the negative or positive peak voltage of signal selected by VTVM SEL SW described below. The positions and functions of the switch are as follows: *Position* — *Function* POS PEAK ---------------- Indicates peak positive video voltage applied to vtvm. NEG PEAK ---------------- Indicates peak negative video voltage applied to vtvm.

Control	Function
LINE VOLTS meter (M3) (fig. 86)	Indicates primary power input voltage to the radio set.
POWER circuit breaker (CB1) (fig. 86)	Applies primary power to the transmitting equipment.
TRANSMITTER OPERATING indicator lamp (I 1) (fig. 86).	Lights when entire transmitting equipment, including order-wire transmitter and power supplies, is operating properly and emitting power.
METER B (M1) and meter switch (S3) (fig. 86).	A 10-position rotary switch which connects the meter to various circuits in the transmitter. As in the case of meter M2 and switch S4, the meter and switch function to facilitate maintenance, realinement, and readjustment of radio transmitter. Positions and functions are as follows:

Position	*Function*
AFC 2ND MULT GRID	Indicates drive to afc second multiplier V12 grid.
WAVEMETER	Indicates wavemeter tuning. Wavemeter is tuned to frequency when meter reading is maximum and is used to determine the klystron frequency.
PA GRID CUR.	Indicates drive to power amplifier V37.
PA POWER OUT	Indicates output power of power amplifier V37.
ORDER-WIRE CARR LEVEL.	Indicates relative amount of order-wire carrier present in the rf output as detected by monitoring circuits of the transmitter.
PA PLATE V	Indicates plate voltage of power amplifier V37.
+300V	Indicates output voltage of the +300-volt supply.
+250V	Indicates output voltage of the +250-volt supply.
+150V	Indicates output voltage of the +150-volt supply.
−150V	Indicates output voltage of the −150-volt supply.

Control	Function
REFL VOLT SUPPLY ADJ (R72) (fig. 87)	Adjusts −2,000-volt supply output voltage from the electronic voltage regulator.
ST LEVEL screwdriver control (R169)	Adjusts output level of sawtooth oscillator V27.
VTVM ZERO BAL NEG screwdriver control (R198) (fig. 88).	Adjusts zero setting PEAK VTVM meter M4 when switch S5 is in NEG PEAK position and S2 is in GND position.
VTVM ZERO BAL POS screwdriver control (R196) (fig. 88).	Adjusts zero setting of PEAK VTVM meter M4 when switch S5 is in POS PEAK position and S2 is in GND position.
VTVM SENS screwdriver control (R197) (fig. 88).	Adjusts sensitivity of PEAK VTVM meter M4. **Note.** This is a calibration adjustment and should be performed only at a depot.
VTVM SEL SW selector switch (S2) (fig. 88)	A four-position rotary switch which selects the input to the vtvm. Positions and functions are as follows:

Position	*Function*
GND	Grounds the input to the vtvm for test purposes.
MOD OUT	Connects PEAK VTVM meter to the modulator output.
MON OUT	Connects PEAK VTVM to the monitor receiver output.
MOD IN	Connects PEAK VTVM to the modulator input.

Control	Function
1ST MULT TUNING screwdriver control (fig. 89).	Tunes afc oscillator and multiplier V11.
NEUT screwdriver control (L6) (fig. 89)	Neutralizes afc oscillator and multiplier V11.
2ND MULT GRID TUN screwdriver control (C40) (fig. 89).	Tunes grid circuit of afc second multiplier V12.
MIX TUN STUB sliding control (fig. 89)	Tunes mixer cavity Z2.
REFL VOLTS ADJUST control (R250) (fig. 86).	Adjusts reflector voltage of klystron oscillator V38.
VIDEO LEVEL screwdriver control (R135) (fig. 90).	Adjusts video output level of monitor receiver output. **Note.** This is a calibration adjustment for the percent modulation and should be done only at a depot.

Control	Function
MOD INPUT SEL SW selector switch (fig. 91).	A three-position rotary switch which selects the input to the modulator. *Position* *Function* ST Selects a sawtooth input to the modulator for test purposes. VID Selects the normal video input to the modulator. GND Grounds the input to the modulator for test purposes.
INPUT VIDEO LEVEL screwdriver control (R2) (fig. 91).	Adjusts video input level to modulator.
AFC ON-OFF switch (S9) (fig. 86)	In OFF position, disables afc circuit by turning off chopper relay. In ON position, makes afc circuit operative by energizing chopper relay.
MANUAL SWITCH (S6) (fig. 86)	A spring-loaded and centered three-position switch. When switch S6 is held in the FREQUENCY INCREASE position, it operates the afc motor to increase oscillator frequency. When switch S6 is held in the FREQUENCY DECREASE position, it operates the afc motor to decrease oscillator frequency.
Klystron screwdriver tuning controls (fig. 92)	Adjusts coarse tuning of klystron oscillator V38.
Klystron small knurled knob	Adjust fine tuning of klystron oscillator V38.
Klystron large knurled knob	Engages afc motor clutch.
SLUG TUNER SLIDING controls	Adjust impedance match between the output of klystron oscillator V38, and the input to power amplifier V37.
CATHODE TUNING control (fig. 93)	Adjusts tuning in the cathode circuit of power amplifier V37.
PLATE TUNING control (fig. 93)	Adjusts tuning in the plate circuit of power amplifier V37.
Power amplifier output-probe carriage assembly.	Permits horizontal positioning of the power amplifier coupling probe for impedance matching. When positioned, the assembly is locked in place by means of a knurled screw marked **LOCK**.
Power amplifier output-probe injection control (fig. 93).	Permits vertical positioning of the power amplifier output coupling probe for proper output loading.
Wavemeter micrometer tuning control (fig. 86).	Adjusted for maximum indication on meter M1 with switch S3 in the WAVEMETER position to determine frequency of klystron.
MON OW PLATE TUN (L31) (fig. 88)	Adjust tuning in plate circuit of monitor amplifier V34.

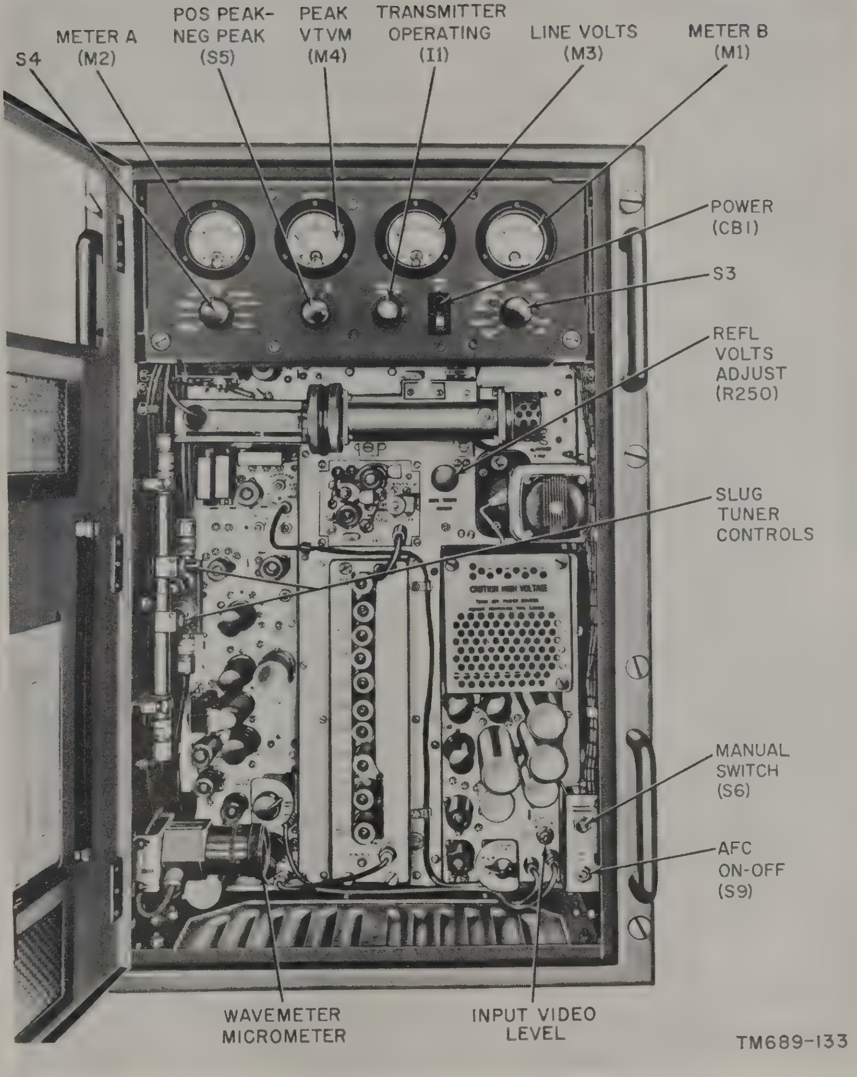

S4
METER A (M2)
POS PEAK-NEG PEAK (S5)
PEAK VTVM (M4)
TRANSMITTER OPERATING (I1)
LINE VOLTS (M3)
METER B (M1)
POWER (CB1)
S3
REFL VOLTS ADJUST (R250)
SLUG TUNER CONTROLS
MANUAL SWITCH (S6)
AFC ON-OFF (S9)
WAVEMETER MICROMETER
INPUT VIDEO LEVEL
TM689-133

Figure 86. Radio transmitter, main chassis controls.

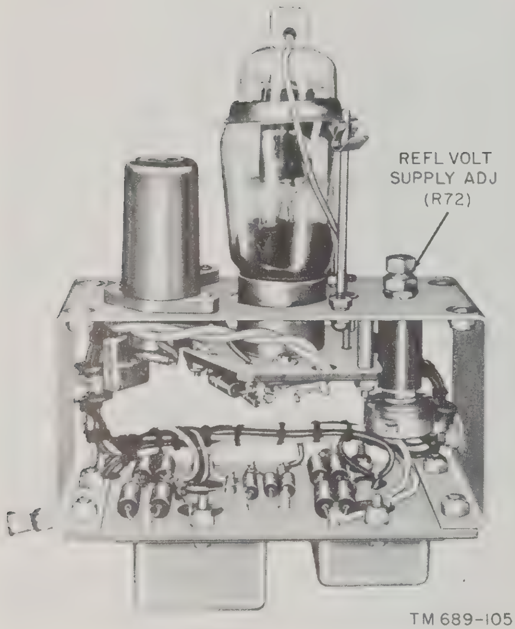

REFL VOLT
SUPPLY ADJ
(R72)
TM 689-105

Figure 87. Electronic voltage regulator, subchassis control.

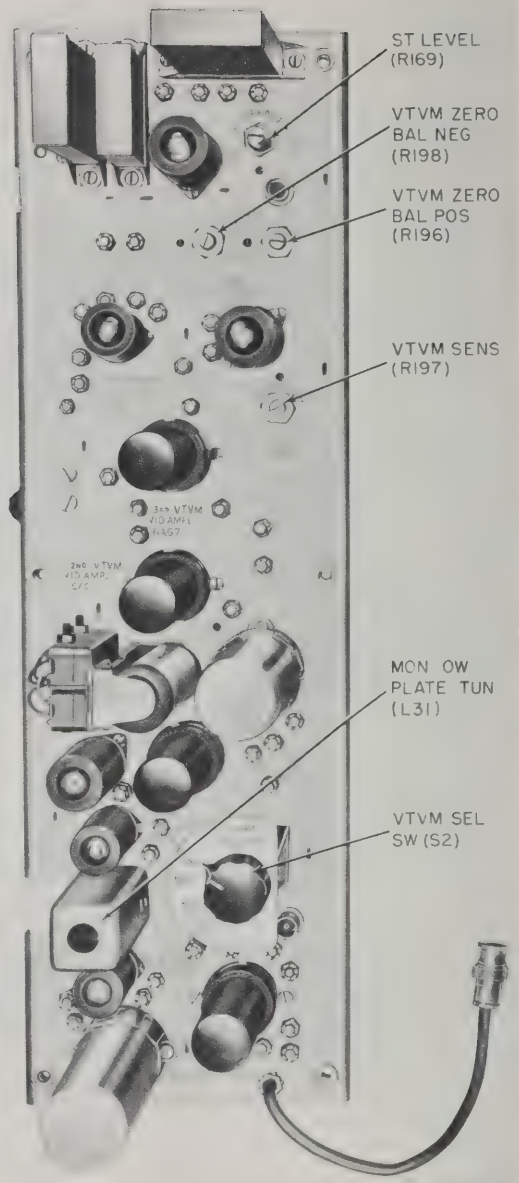

ST LEVEL
(R169)
VTVM ZERO
BAL NEG
(R198)
VTVM ZERO
BAL POS
(R196)
VTVM SENS
(R197)
3RD VTVM
VID AMPL
6AG7
2ND VTVM
VID AMPL
MON OW
PLATE TUN
(L31)
VTVM SEL
SW (S2)
TM 689-151

Figure 88. Vtvm subchassis controls.

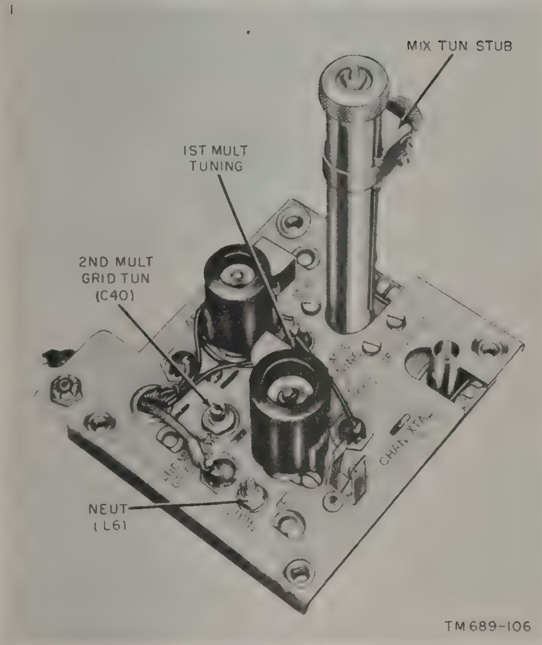

MIX TUN STUB
1ST MULT TUNING
2ND MULT GRID TUN (C40)
CHAN XTAL
NEUT (L6)
TM 689-106

Figure 89. Crystal multiplier controls.

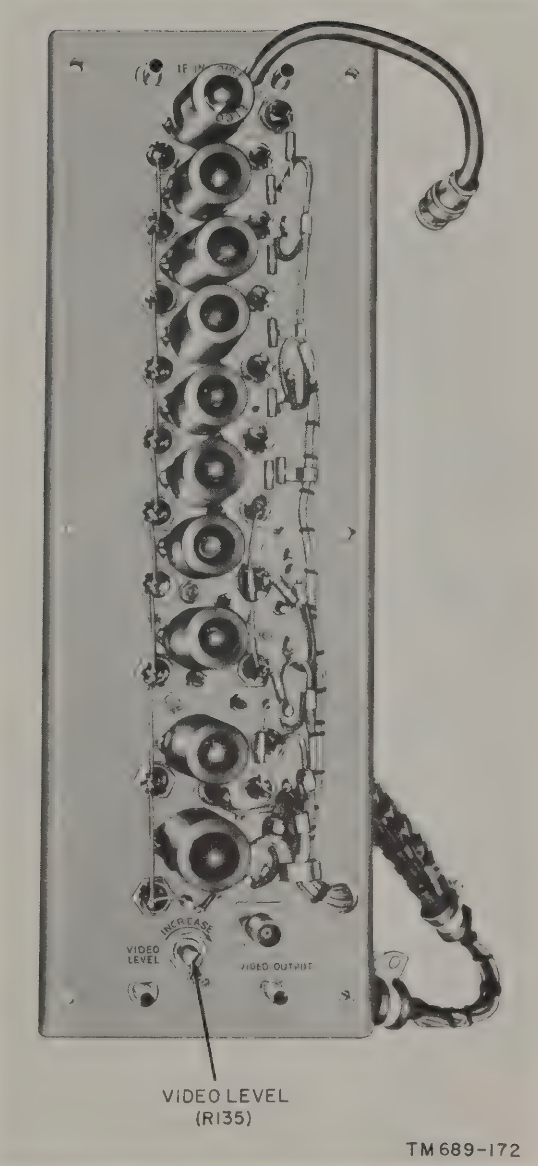

INCREASE
VIDEO LEVEL
VIDEO OUTPUT
VIDEO LEVEL (R135)
TM 689-172

Figure 90. If. amplier control.

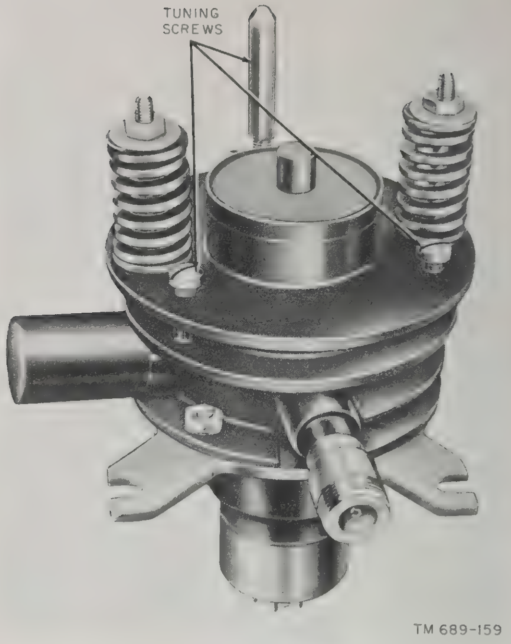

TUNING SCREWS
TM 689-159

Figure 92. Klystron tuning screws.

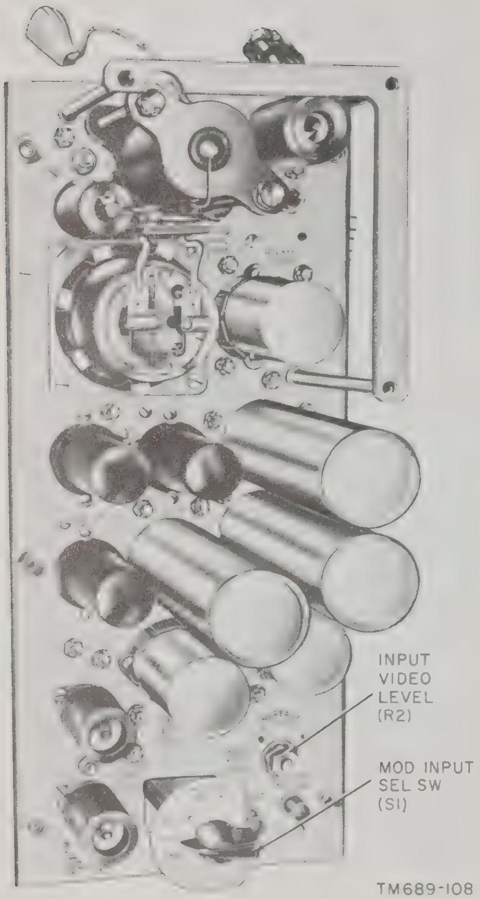

INPUT VIDEO LEVEL (R2)
MOD INPUT SEL SW (S1)
TM689-108

Figure 91. Modulator control.

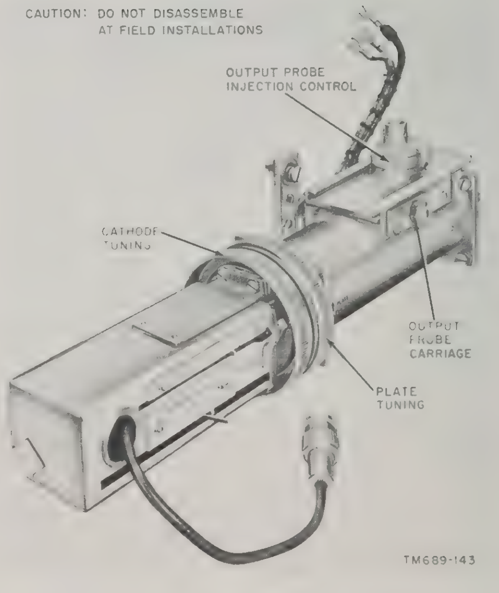

CAUTION: DO NOT DISASSEMBLE AT FIELD INSTALLATIONS
OUTPUT PROBE INJECTION CONTROL
CATHODE TUNING
OUTPUT PROBE CARRIAGE
PLATE TUNING
TM689-143

Figure 93. Power amplifier controls.

67. Power Supply PP–764/G (figs. 94 and 95)

The chart below lists the controls and indicators of the radio transmitter high-voltage power supply and the function of each item.

Control	Function
POWER ON indicator lamp (I 1)	Lights when POWER circuit breaker CB1 on radio transmitter meter panel is turned on. This applies primary voltage to transformer T5 which supplies filament voltage to all filaments of radio transmitter and power amplifier high-voltage rectifier.
HV PLATE ON indicator lamp (I 2)	Lights when the KLYSTRON HV circuit breaker, CB7, is turned on, and the following switches are on: POWER, CB1, in radio transmitter; FIL, CB2, in order-wire receiver and INPUT POWER BREAKER, CB1 and CB2; HV FILAMENT, CB4; LV FILAMENT, CB3; BIAS V −150V, CB5, and LV PLATE, CB6.
HV FILAMENT circuit breaker (CB4)	Applies filament power to radio transmitter high-voltage power supply, and protects circuit from overload.
LV FILAMENT circuit breaker (CB3)	Applies filament power to the transmitter low-voltage power supply, and protects circuit from overload.
BIAS V −150V circuit breaker (CB5)	Applies −150-volt bias voltage to the radio transmitter and protects circuit from overload.
LV PLATE circuit breaker (CB6)	Applies low plate voltage to the radio transmitter and protects circuit from overload.
KLYSTRON HV circuit breaker (CB7)	Applies high voltage to transmitter klystron V38, and protects circuit from overload with S2 in PA PLATE VOLTAGE ADJUST position.
PA PLATE circuit breaker (CB8)	Applies high voltage to radio transmitter power amplifier V37, with S2 in PA PLATE VOLTAGE ADJUST position and protects circuit from overload.
VARIABLE AUTOTRANSFORMER control (T3).	With switch S2 in PA PLATE VOLTAGE ADJUST position, T3 adjusts the plate voltage of radio transmitter power amplifier V37 for proper operation. With switch S2 in KLYSTRON BEAM VOLTAGE TEST ADJUST position, T3 adjusts the beam voltage of klystron oscillator V38 under test conditions (particularly during klystron break-in procedure).
PA PLATE VOLTAGE ADJUST-KLYSTRON BEAM VOLTAGE TEST ADJUST switch (S2).	In PA PLATE VOLTAGE ADJUST position, the switch places the variable autotransformer in primary circuit of the plate supply of radio transmitter power amplifier V37. In the KLYSTRON BEAM VOLTAGE TEST ADJUST position, the switch places the variable autotransformer in the primary circuit of the beam supply of radio transmitter klystron oscillator V38.
BEAM V ADJUST screwdriver control (R36)	Adjusts the −1,000-volt beam-voltage supply.
INPUT POWER BREAKER circuit breakers (CB1 and CB2).	Permits ac line power to be applied to the components of the radio set and protects equipment from an overload.

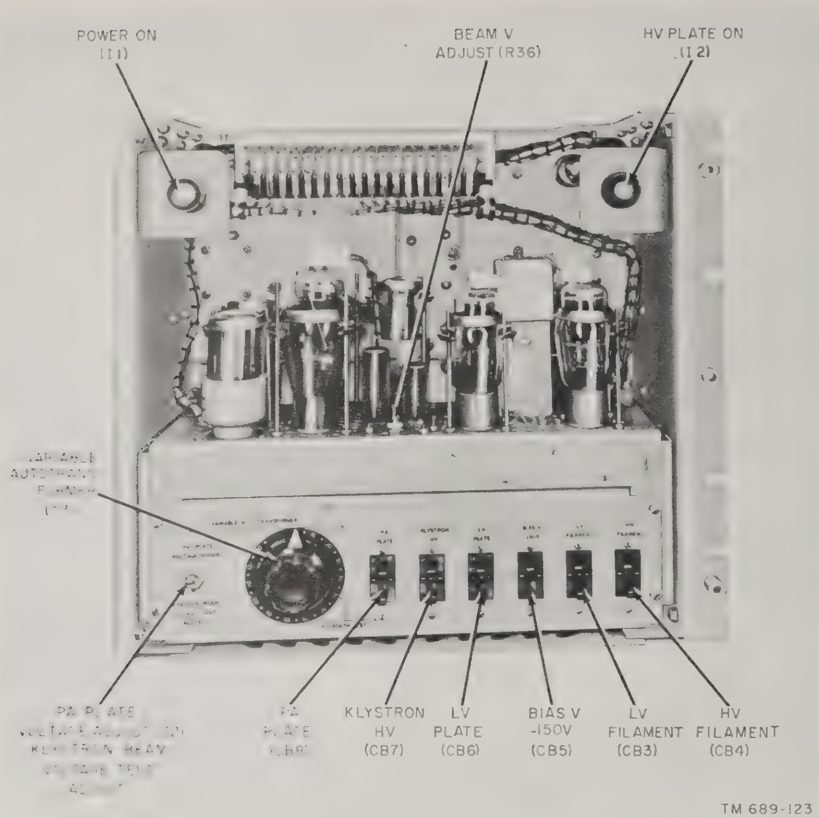

POWER ON (I1)
BEAM V ADJUST (R36)
HV PLATE ON (I2)
VARIABLE AUTOTRANSFORMER (T1)
PA PLATE VOLTAGE ADJUST (2) KLYSTRON BEAM VOLTAGE TEST ADJUST
PA PLATE (CB8)
KLYSTRON HV (CB7)
LV PLATE (CB6)
BIAS V -150V (CB5)
LV FILAMENT (CB3)
HV FILAMENT (CB4)
TM 689-123

Figure 94. Power Supply PP–764/G controls, front panel.

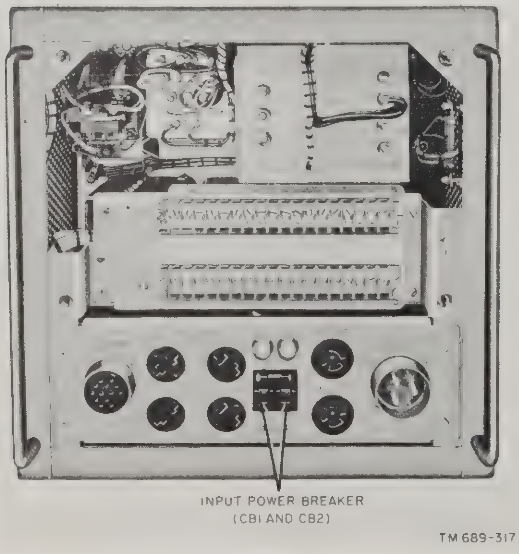

INPUT POWER BREAKER (CB1 AND CB2)
TM 689-317

Figure 95. Power Supply PP–764/G controls. rear panel.

68. Order-Wire Receiver R–543/TRC–29 (figs. 96 and 97)

The chart below lists the controls and instruments of the order-wire receiver and the function of each item.

<table>
<tr><th>Control</th><th colspan="2">Function</th></tr>
<tr><td>Meter (M1) and meter switch (S1)</td><td colspan="2">A seven-position rotary switch that connects the meter to various circuits.</td></tr>
<tr><td></td><td>Position</td><td>Function</td></tr>
<tr><td></td><td>OW CARR LEVEL</td><td>Indicates relative amplitude of incoming order-wire carrier.</td></tr>
<tr><td></td><td>DISCR+</td><td>Indicates whether incoming order-wire carrier frequency is higher than discriminator center frequency.</td></tr>
<tr><td></td><td>DISCR−</td><td>Indicates whether incoming order-wire carrier frequency is lower than discriminator center frequency.</td></tr>
<tr><td></td><td>AUDIO</td><td>Indicates audio level in local handset.</td></tr>
<tr><td></td><td>+140V</td><td>Indicates order-wire receiver power supply voltage level.</td></tr>
<tr><td></td><td>DIV CONT LEVEL</td><td>Used only in diversity operation. Indicates output level of noise comparison circuit in preferred receiver and a fixed reading in the standby order-wire receiver.</td></tr>
<tr><td></td><td>DIV OPER</td><td>Indicates whether the receiver under check in diversity is in operation.</td></tr>
<tr><td>TRANSFER CONTROL ON indicator lamp (I 1).</td><td colspan="2">Lights when operation with switchover equipment is selected.</td></tr>
<tr><td>RING push button switch (S5)</td><td colspan="2">Initiates a ring signal in the order-wire for transmission to all stations of the radio link.</td></tr>
<tr><td>SERVICE SELECTOR switch (S3)</td><td colspan="2">A three-position selector switch that selects DIV, NORMAL, or TRANSFER CONTROL operation of the receiver.</td></tr>
<tr><td>BUZZER CONTROL switch (S2) and indicator alarm buzzer (I 2).</td><td colspan="2">In the NORMAL position, switch S2 operates the indicator buzzer, I 2, and the remote handset bell when a carrier failure occurs. In the MONITOR position, it operates the indicator buzzer and remote handset bell when operation is resumed.</td></tr>
<tr><td>FIL circuit breaker (CB1)</td><td colspan="2">Applies filament power to the order-wire receiver and protects circuit from overload.</td></tr>
<tr><td>PLATE circuit breaker (CB2)</td><td colspan="2">Applies plate power to the order-wire receiver and protects circuit from overload.</td></tr>
<tr><td>AUDIO LEVEL screwdriver control (R26)</td><td colspan="2">Adjusts order-wire receiver audio level.</td></tr>
<tr><td>+140V ADJ (R74)</td><td colspan="2">Adjusts the order-wire receiver +140-volt plate supply.</td></tr>
<tr><td>DIVERSITY CALIBRATE screwdriver control (R50).</td><td colspan="2">Adjusts the level of the diversity noise-measuring circuit of the order-wire receiver.</td></tr>
<tr><td>DIVERSITY PREFERENCE screwdriver control (R54).</td><td colspan="2">Adjusts the point in relative signal-to-noise ratio at which video circuits are switched from one diversity receiver to another, in diversity operation.</td></tr>
<tr><td>ALM SENS (R81)</td><td colspan="2">Adjusts the point at which an alarm signal is initiated.</td></tr>
</table>

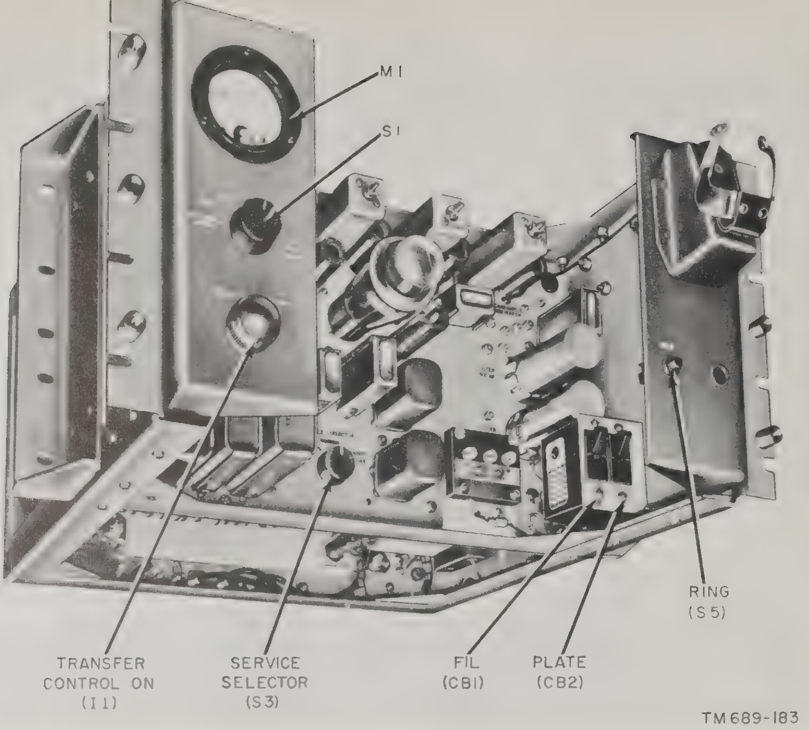

M1
S1
TRANSFER CONTROL ON (I1)
SERVICE SELECTOR (S3)
FIL (CB1)
PLATE (CB2)
RING (S5)
TM689-183

Figure 96. Order-Wire Receiver R–543/TRC–29, controls on front panel.

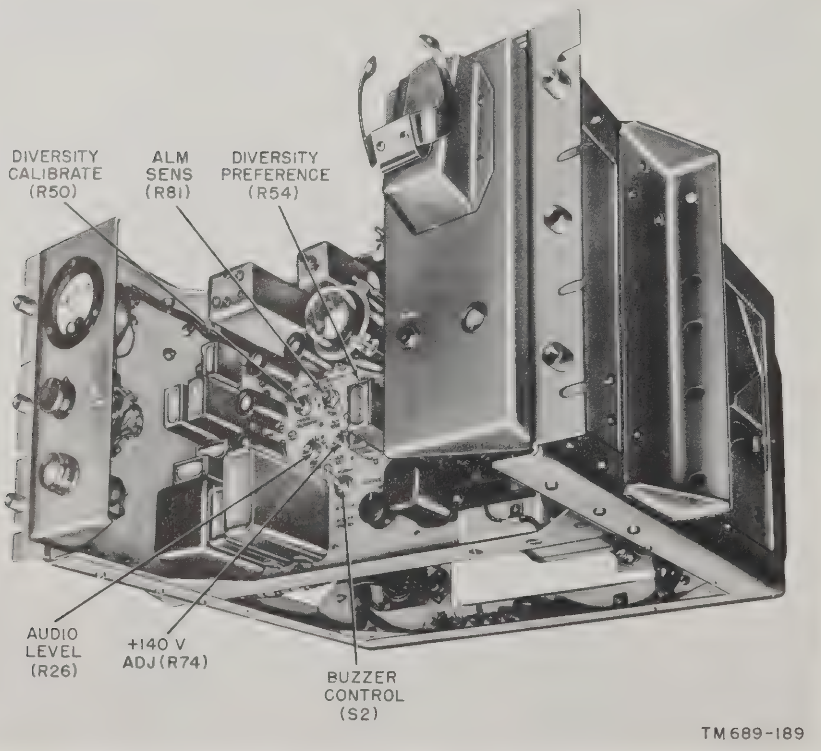

DIVERSITY CALIBRATE (R50)
ALM SENS (R81)
DIVERSITY PREFERENCE (R54)
AUDIO LEVEL (R26)
+140 V ADJ (R74)
BUZZER CONTROL (S2)
TM689-189

Figure 97. Order-Wire Receiver R–543/TRC–29, controls on rear panel.

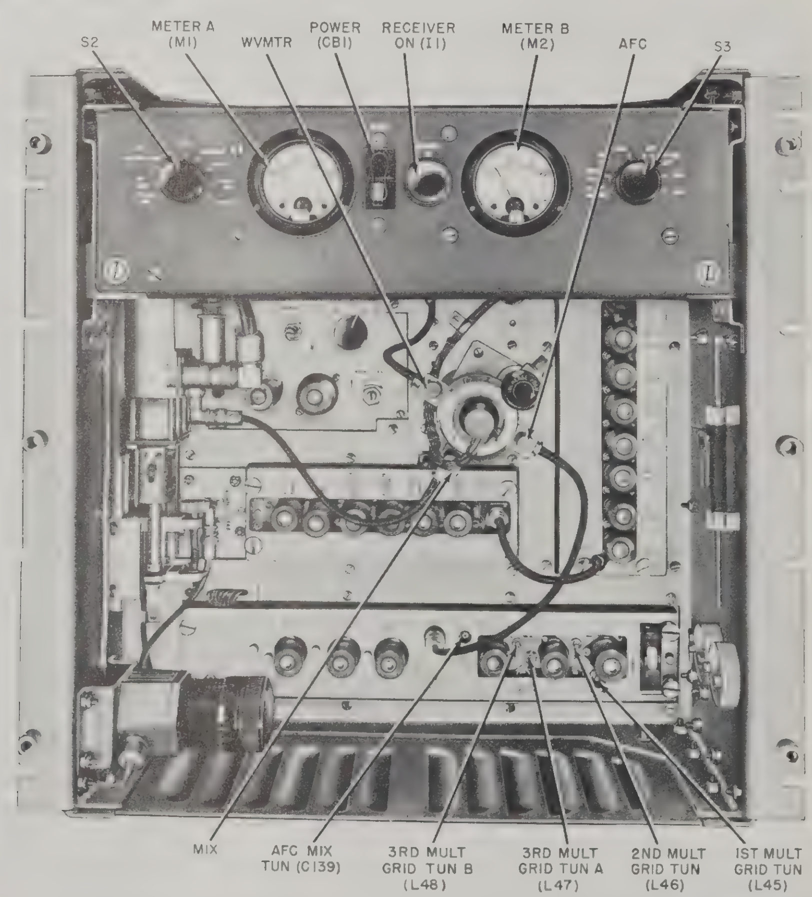
69. Radio Receiver R–418/G

(figs. 98, 99, and 100)

The chart below lists the controls and instruments of the radio receiver and the function of each item.

<table>
<tr><th>Control</th><th>Function</th></tr>
<tr><td>METER A (M1) and meter switch (S2)</td><td>A nine-position, two-wafer rotary switch that connects meter M1 to various circuits. The function of meter M1 and switch S2 is to permit monitoring of a point in the equipment to facilitate routine maintenance and to provide a means for realinement and readjustment of the receiver without using external meters.
<table>
<tr><th><i>Position</i></th><th><i>Function</i></th></tr>
<tr><td>AFC 2ND MULT GRID</td><td>Indicates drive on afc second multiplier, V23, grid.</td></tr>
<tr><td>AFC MIXER</td><td>Indicates drive from crystal multiplier chain and rf output.</td></tr>
<tr><td>AFC CORRECTION+ and AFC CORRECTION−</td><td>Indicates frequency error (positive or negative) of local oscillator.</td></tr>
<tr><td>IF. LEVEL</td><td>Indicates radio receiver if. level at first limiter grid V13.</td></tr>
<tr><td>WAVEMETER</td><td>Indicates wavemeter tuning. Adjusted for maximum meter reading to determine frequency of local oscillator.</td></tr>
<tr><td>REFL V</td><td>Indicates relative reflector voltage of klystron local oscillator V21.</td></tr>
<tr><td>BEAM CUR.</td><td>Indicates relative current of klystron local oscillator V21.</td></tr>
<tr><td>BEAM V</td><td>Indicates relative beam voltage of klystron local oscillator.</td></tr>
</table></td></tr>
<tr><td>POWER circuit breaker (CB1)</td><td>Applies primary power to the receiver.</td></tr>
<tr><td>RECEIVER ON indicator lamp (I 1)</td><td>Lights when primary power is applied to all receiving equipment circuits.</td></tr>
<tr><td>METER B (M2) and meter switch (S3)</td><td>An eight-position, two-wafer rotary switch that connects the meter to various circuits. As in case of M1 and S2, this meter and switch function to facilitate maintenance, realinement, and readjustment of radio receiver.
<table>
<tr><th><i>Position</i></th><th><i>Function</i></th></tr>
<tr><td>AFC 1ST MULT GRID</td><td>Indicates drive on afc first multiplier, V22B, grid.</td></tr>
<tr><td>AFC 3RD MULT GRID</td><td>Indicates drive on third multiplier, V24, grid.</td></tr>
<tr><td>AFC IF. LEVEL</td><td>Indicates radio receiver afc if. level at third if. amplifier grid V27.</td></tr>
<tr><td>IF. MIXER</td><td>Indicates radio receiver if. mixer level.</td></tr>
<tr><td>IF. DISCR FREQ HIGH and IF. DISCR FREQ LOW</td><td>Indicates relationship of if. to if. discriminator crossover when local oscillator is operating properly.</td></tr>
<tr><td>+150V</td><td>Indicates voltage of radio receiver +150-volt supply.</td></tr>
<tr><td>+250V</td><td>Indicates voltage of radio receiver +250-volt supply.</td></tr>
</table></td></tr>
<tr><td>1ST MULT GRID TUN screwdriver control (L45).</td><td>Tunes the drive to the grid circuit of the first afc multiplier, V22.</td></tr>
<tr><td>2ND MULT GRID TUN screwdriver control (L46).</td><td>Tunes the drive to the grid circuit of the second afc multiplier, V23.</td></tr>
<tr><td>3RD MULT GRID TUN A and 3RD MULT GRID TUN B screwdriver controls (L47 and L48).</td><td>Tune the drive to the grid of the third afc multiplier, V24.</td></tr>
<tr><td>AFC MIX TUN screwdriver control (C139)</td><td>Tunes the input of the afc mixer circuit.</td></tr>
<tr><td>IF. LEVEL screwdriver control (R152)</td><td>Adjusts the output level of the radio receiver if. circuit.</td></tr>
<tr><td>REFL V screwdriver control (R146)</td><td>Provides adjustment of the klystron local-oscillator reflector voltage.</td></tr>
</table>

Control	Function
BEAM CURRENT screwdriver control (R145).	Adjusts the beam current of the klystron local oscillator, V21.
AFC switch (S1)	In the ON position, completes the afc correction loop. In the OFF position, disconnects the afc circuit by opening loop.
VIDEO LEVEL screwdriver control (R75)	Adjusts output level of video preamplifier.
INCREASE FREQ control	Adjusts frequency of klystron local oscillator, V21.
Wavemeter micrometer	In conjunction with chart inside radio receiver door, meter M1, and meter switch S2, measures klystron local-oscillator frequency.
Rf preselector carriage tuning	Tunes rf preselector cavities, Z1.
Rf preselector primary shorting plunger	Normally in lower position, detunes preselector primary when in upper position.
Rf preselector secondary shorting plunger	Normally in lower position, detunes preselector secondary cavity in upper position.
Rf preselector vernier tuning screw	Tunes preselector primary cavity.
Probe in klystron assembly MIX. connection	Adjusts klystron output to if. mixer circuit.
Probe in klystron assembly AFC connection	Adjusts klystron output to afc circuits.
Probe in klystron assembly WVMTR connection.	Adjusts klystron output to wavemeter.


S2
METER A (M1)
WVMTR
POWER (CB1)
RECEIVER ON (I1)
METER B (M2)
AFC
S3
MIX
AFC MIX TUN (C139)
3RD MULT GRID TUN B (L48)
3RD MULT GRID TUN A (L47)
2ND MULT GRID TUN (L46)
1ST MULT GRID TUN (L45)

TM689-148

Figure 98. Radio receiver controls, meter panel down.

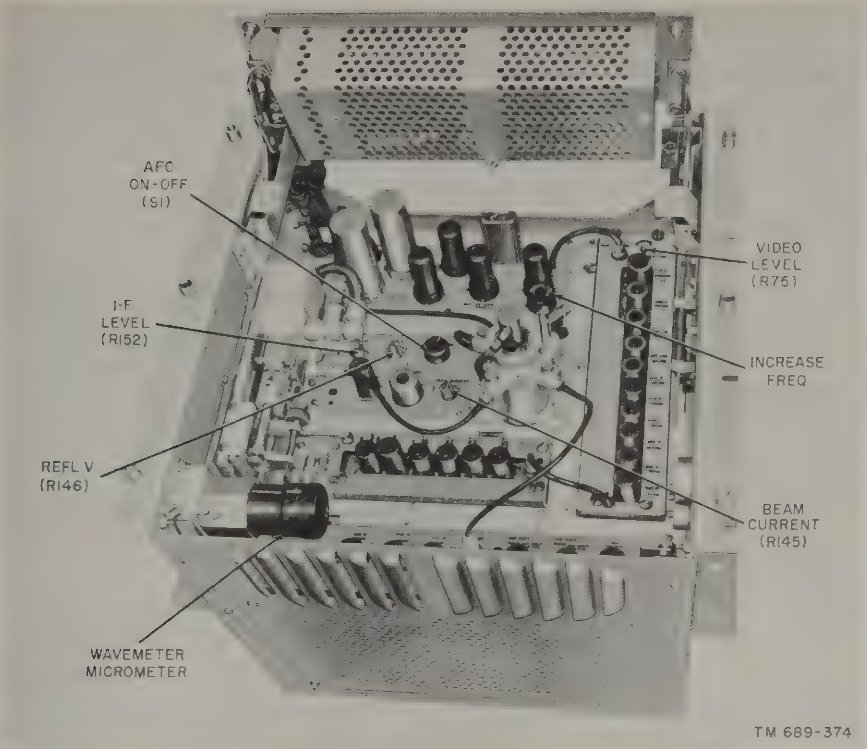

AFC
ON-OFF
(S1)
I-F
LEVEL
(R152)
REFL V
(R146)
WAVEMETER
MICROMETER
VIDEO
LEVEL
(R75)
INCREASE
FREQ
BEAM
CURRENT
(R145)
TM 689-374

Figure 99. Radio receiver controls, meter panel up.

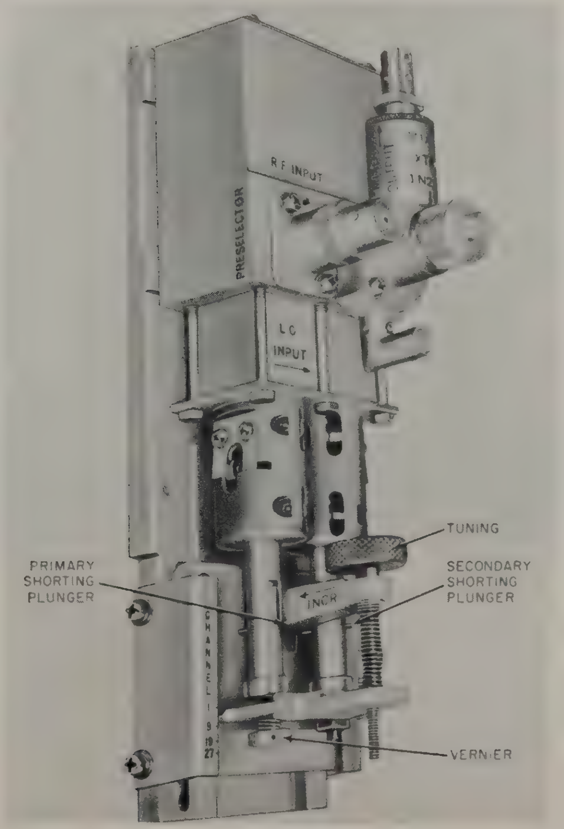

R F INPUT
PRESELECTOR
LO
INPUT
TUNING
PRIMARY
SHORTING
PLUNGER
SECONDARY
SHORTING
PLUNGER
INCR
CHANNEL
VERNIER

*Figure 100.
Preselector controls.*

70. Power Supply PP–690/G

(fig. 101)

The chart below lists the controls and indicators of the receiver power supply and the functions of each item.

Control	Function
HV FIL circuit breaker (CB3)	Turns on the high-voltage filament supply for the radio receiver and protects circuit from overload.
LV PL circuit breaker (CB1)	Turns on the low-voltage plate supply for the radio receiver and protects circuit from overload.
HV PL circuit breaker (CB2)	Turns on the high-voltage plate supply for the radio receiver and protects circuit from overload.
POWER on indicator lamp (I 2)	Lights when the POWER circuit breaker (CB1) in radio receiver is turned on, and INPUT POWER BREAKER CB1 and CB2 in high-voltage power supply are ON.
PLATE ON indicator lamp (I 1)	Lights when the HV PLATE circuit breaker (CB2) is turned on, and the POWER, CB1, in radio receiver, and LV PL (CB1), HV PL (CB2), and HV FIL (CB3), are on.
+250V ADJ. screwdriver control (R32)	Adjusts the radio receiver +250-volt plate supply.
+150V ADJ. screwdriver control (R10)	Adjusts the radio receiver +150-volt plate supply.
BEAM V ADJ (R44)	Adjusts beam voltage of the radio receiver supply.

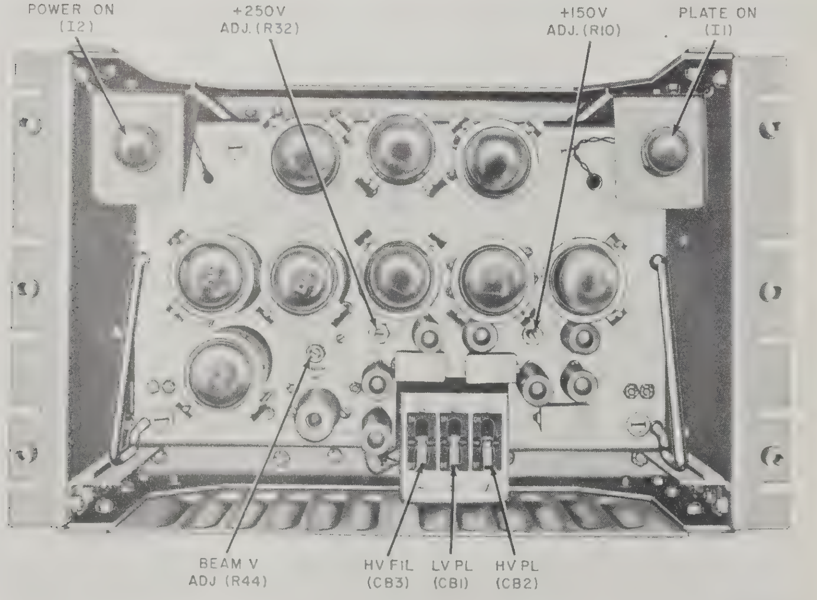


Figure 101. Power Supply PP–690/G controls.

71. Power Supply PP–689/G
(fig. 102)

The chart below lists the controls and indicators of the radio transmitter low-voltage power supply, and the function of each item.

Control	Function
+250V ADJ. screwdriver control (R26)	Adjusts the radio transmitter +250-volt supply.
+150V ADJ. screwdriver control (R42)	Adjusts the radio transmitter +150-volt supply.
+300V ADJ. screwdriver control (R9)	Adjusts the radio transmitter +300-volt supply.
FIL ON indicator lamp (I 1)	Lights up when the LV FILAMENT circuit breaker, CB3, on the radio transmitter high-voltage power supply is turned on, and POWER (CB1), in radio transmitter, INPUT CIRCUIT BREAKER (CB1 and CB2), and HV FILAMENT (CB4) are on.
LV PLATE ON indicator lamp (I 2)	Lights up when the LV PLATE circuit breaker (CB6) on the radio transmitter high-voltage power supply is turned on, and FIL ON lamp (I 1) and BIAS V −150V (CB5) circuit breaker are on.

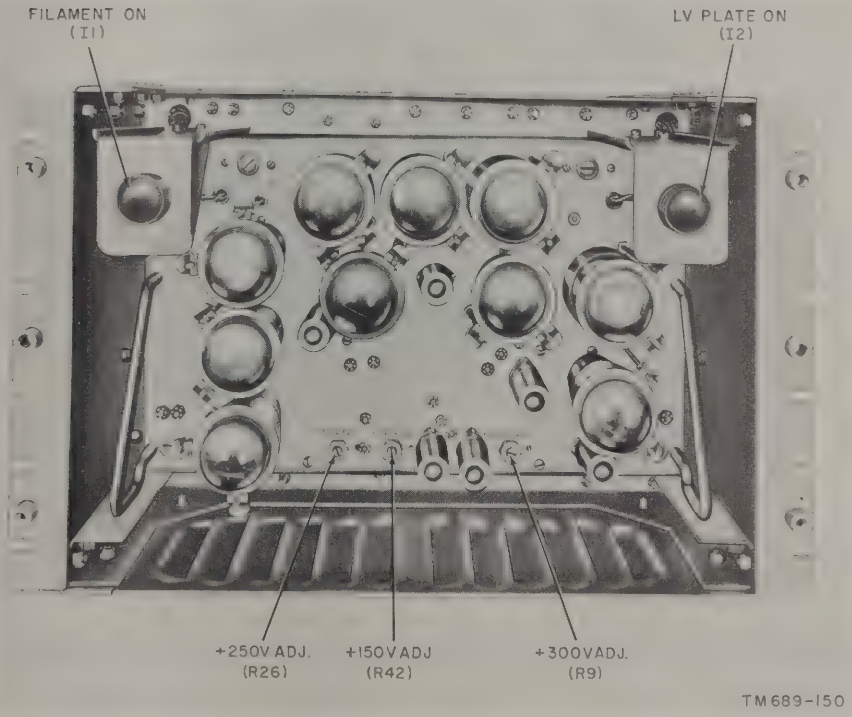


Figure 102. Power Supply PP–689/G controls.

72. Accessories

a. Fixed Autotransformer Power Transformer TF–146/G (fig. 103). The chart below lists the controls located on the autotransformer and the function of each control.

b. Switchbox SA–357/G. The switchbox contains only one control, marked INPUT SELECTOR SWITCH (S1), which selects the primary input source.

c. Handset-Signaling Unit H–102/TRC–29. This remote handset unit has two pushbutton controls. One control is on the chassis side and is depressed to initiate a ring. The second control is on the handset and is pushed to talk.

Control	Function
INCREASE OUTPUT switch (S1)	Varies output voltage of autotransformer in approximately 5- to 6-volt steps.
230V circuit breaker (CB1)	Normally in the ON position when latch is closed. Protects 230-volt primary input from overload and applies this voltage to transformer T1.
115V circuit breaker (CB2)	Normally in the ON position when latch is closed. Protects 115-volt primary input from overload and applies this voltage to transformer T1.

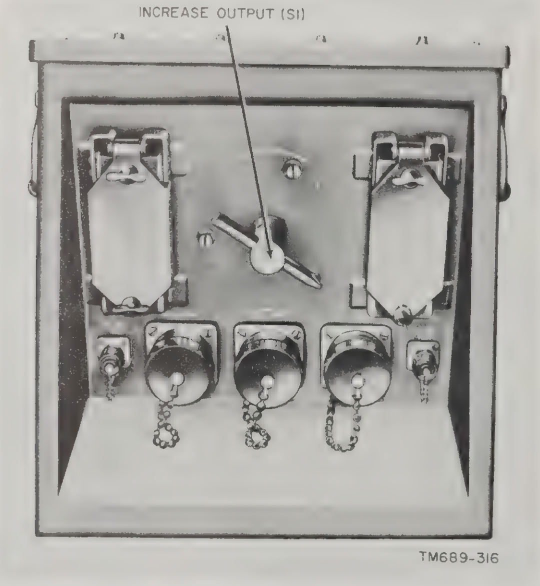


Figure 103. Autotransformer controls.

Section V. PRELIMINARY ADJUSTMENT OF RADIO SET AN/TRC–29

73. General

All radio sets (operating and spare) are now ready to be placed in operation and tuned to their intended channel frequencies (par. 39). In addition, some preliminary adjustments of each radio set can be made on an equipment basis. These adjustments should be made on all sets in the stations (spare and operating). The adjustment procedures are described in this section. Further adjustment of each radio set will be required for system operation.

74. Setting of Controls Before Power Is Applied

Before any power is applied to the equipment, the controls should be set as indicated in the chart below.

Note. Refer to paragraphs 65 through 72 for location, function, and illustration of all controls described in this and succeeding sections. It is recommended that these paragraphs be reviewed before proceeding with the radio set adjustments. For location and illustration of receptacles, refer to paragraph 54.

Location of control	Control	Setting
Order-Wire Transmitter T–389/TRC–29	ORDER WIRE TEST SWITCH	OPR.
	Dc meter selector switch	AUDIO.
	TRANSFER CONTROL-MANUAL OPERATE	MANUAL OPERATE.
	FIL	OFF.
	PLATE	OFF.
	ORDER WIRE CARR LEVEL	Fully counter-clockwise.
Radio Transmitter T–303/G	POWER	OFF.
	MOD INPUT SEL SW	GND.
	AFC	OFF.
	VTVM SEL SW	MON OUT.
Power Supply PP–764/G	HV FILAMENT	OFF.
	LV FILAMENT	OFF.
	BIAS V −150 V	OFF.
	LV PLATE	OFF.
	KLYSTRON HV	OFF.
	PA PLATE	OFF.
	PA PLATE VOLTAGE ADJUST-KLYSTRON BEAM VOLTAGE TEST ADJUST.	KLYSTRON BEAM VOLTAGE TEST ADJUST.
	VARIABLE AUTOTRANSFORMER	0.
	INPUT POWER BREAKER	OFF.
Order-Wire Receiver R–543/TRC–29.	Meter selector switch	AUDIO.
	SERVICE SELECTOR	NORMAL.
	BUZZER CONTROL	MONITOR.
	FIL	OFF.
	PLATE	OFF.
Radio Receiver R–418/G	POWER	OFF.
	AFC	OFF.
Power Supply PP–690/G	HV FIL	OFF.
	LV PL	OFF.
	HV PL	OFF.
Switchbox SA–357/G	INPUT SELECTOR SWITCH	2.

Note. The remainder of this section covers procedures for tuning and adjusting the radio set. In these procedures, reference is made to meter readings and other indications that should be obtained if the equipment is operating properly. If these readings and indications are not obtained, refer to the equipment performance checklist.

75. Tuning and Adjustment of Transmitting Equipment

The transmitting equipment is tuned and adjusted in accordance with the procedures given in the following paragraphs. After the equipment is tuned, allow a 1-hour warmup period, then repeat the tuning procedure.

76. Tuning Transmitter Crystal Multiplier Chain

a. Application of Power. It is necessary to apply only low-voltage dc power to the transmitter to tune the transmitter multiplier chain. The high-voltage power should *not* be applied to the transmitter at this time. The following procedure should be used to apply the low-voltage power to the transmitter:

(1) Make sure that all protective dust

covers on the rear of the transmitter and receiver racks are securely in place. These dust covers operate interlock switches that must be closed before plate power can be applied to the transmitter. In addition, make sure that TRANSFER CONTROL-MANUAL OPERATE switch in the orderwire transmitter is in the MANUAL OPERATE position.

(2) Place the INPUT POWER BREAKER circuit breaker on the rear of the high-voltage power supply in the ON position.

(3) Check the meter reading of the LINE VOLTS meter on the radio transmitter. If this reading is not 115 volts, adjust the INCREASE OUTPUT control on the autotransformer for a reading as close to 115 volts as possible.

(4) Place the POWER switch in the radio transmitter in the ON position. The POWER ON lamp in the high-voltage power supply should go on.

(5) Place the HV FILAMENT switch in the high-voltage power supply in the ON position.

(6) Place the LV FILAMENT switch in the high-voltage power supply in the ON position. The FILAMENT ON lamp on low-voltage power supply (in receiver rack) should go on.

(7) Place the FIL switch in the orderwire transmitter in the ON position.

(8) Place the BIAS V —150-V switch on the high-voltage supply in the ON position.

(9) Place the LV PLATE switch on the high-voltage power supply in the ON position. After about 60 seconds the LV PLATE ON lamp in the low-voltage power supply should go on.

(10) Recheck the LINE VOLTS meter reading. If it is not 115 volts, readjust the INCREASE OUTPUT control on the autotransformer for a reading as close as possible to 115 volts.

(11) Place the right hand meter selector switch on the radio transmitter in —150-V position. Note the right hand meter (METER B) reading. It should be between 95 and 105.

(12) Place the right hand meter selector switch in the +150V position. The meter reading should be between 95 and 105.

(13) Place the right hand meter selector switch in +250V position. The meter reading should be between 95 and 105.

(14) Place the right hand meter selector switch in +300V position. The meter reading should be between 95 and 105.

b. Tuning Procedure. The tuning procedure given below can be used whenever the transmitter crystal multiplier must be tuned. To tune the crystal multiplier circuits, low-voltage power must be applied to the transmitter as described above. The tuning procedure is as follows:

(1) Set the left hand meter selector switch to the AFC 1ST MULT GRID position.

(2) Adjust the 1ST MULT TUNING control from its extreme counterclockwise position to its extreme clockwise position. Note the METER A reading as the control is varied between these two extreme positions. In some cases the meter reading will increase to a maximum value, and then decrease sharply. In other cases, the meter reading will increase to some large value and either decrease very slowly, stay at that value, or increase very slowly. Adjust the OSC MULT TUNING control to the position that provides the maximum value for the first case or just reaches the leveling off point in the second case.

(3) Turn the 1ST MULT TUNING control 1 turn clockwise.

(4) Adjust the NEUT coil so that the AFC 1ST MULT GRID meter reading is at minimum (it should be close to zero).

(5) Retune the 1ST MULT TUNING control for maximum meter reading. This control is set to the proper position when a relatively sharp and symmetrical resonant point is noted. That is, as the proper position is being approached, the meter reading should increase uniformly toward the maximum value; it should reach the maxi-

mum value when this position is reached; and decrease at the same uniform rate as this position is passed. If this type of reading is not obtained, repeat the procedures given in (2), (3), and (4) above.

(6) Set the right hand meter selector switch to the AFC 2ND MULT GRID and adjust the 2ND MULT GRID TUN for maximum reading.

(7) Readjust the 1ST MULT TUNING control for maximum METER A indication and then detune the control counterclockwise for a meter indication that is 90 percent of the maximum reading obtained.

(8) Repeat the procedure given in (6) above.

(9) Set the left hand meter selector switch to the AFC MIXER position and vary the MIX TUN STUB (after loosening the locking screw) through its entire range. The meter may indicate several maximums. Set the MIX TUN STUB to the point that provides the largest maximum meter reading. Lock the control in this setting.

(10) Switch the LV PLATE breaker on the high-voltage power supply off and on several times and note that the oscillator functions each time; that is, the METER A reading returns to the value obtained in (9) above. If it does not, repeat the procedures given in (1) through (9) above.

77. Procedure for Tuning Transmitter Klystron and Power Amplifier

a. Application of Power. In the following paragraphs, it is assumed that low-voltage power has been turned on as described in paragraph 76. Proceed to apply high-voltage power to the klystron as follows:

(1) Make sure that the VARIABLE AUTOTRANSFORMER knob is at O and PA PLATE VOLTAGE ADJUST-KLYSTRON BEAM VOLTAGE TEST ADJUST switch is in the KLYSTRON BEAM VOLTAGE TEST ADJUST position.

(2) Place the KLYSTRON HV and PA PLATE switches on high-voltage power supply in the ON positions. The HV PLATE lamp should go on, and the blower motor should start.

(3) Turn the VARIABLE AUTOTRANSFORMER knob to the point marked 50.

(4) Place the left hand meter selector switch in BEAM V position. The meter reading should be 50. If it is not, readjust the VARIABLE AUTOTRANSFORMER knob for a reading of 50.

(5) Allow a 5-minute warmup period.

Note. If the circuit breaker throws within this 5-minute period, replace the klystron (par. 133*b*).

b. Transmitter Klystron and Power Amplifier Tuning Procedure. Tune the klystron and power amplifier to the proper frequency in the following manner (it is assumed that low-voltage power has already been applied to the transmitter):

(1) Place the KLYSTRON HV and PA PLATE switches in the OFF positions.

(2) Place the PA PLATE ADJUST-KLYSTRON BEAM VOLTAGE TEST ADJUST switch in PA PLATE ADJUST position.

Note. Be sure that the klystron large knurled knob is *loose* (afc motor clutch is *not* engaged).

(3) Turn the VARIABLE AUTOTRANSFORMER knob to the O position.

(4) Place the KLYSTRON HV switch in the ON position.

(5) Place the left hand meter selector switch to the BEAM V position. The meter reading should be between 97 and 103 volts.

(6) Place the left hand meter selector switch to the KLYSTRON POWER OUT position.

(7) Turn the REFL VOLTS ADJUST knob for maximum reading on METER A.

(8) Turn the MOD INPUT SEL SW to the GND position.

(9) Place the right hand meter switch to WAVEMETER.

(10) Turn the wavemeter knob until the maximum right hand meter reading (WAVEMETER) is obtained.

(11) Note the reading of the wavemeter. Use the calibration chart mounted on

the inside of the radio transmitter door to determine the operating frequency of the klystron.

(12) At this point the klystron may not be at the proper operating frequency. Turn the KLYSTRON HV switch to the OFF position. The klystron frequency is changed by varying the spacing between the front plates. This spacing is varied by turning the two tuning screws located on the front of the klystron and the smaller knurled knob on the klystron-motor coupling assembly. The tuning screws are adjusted with a screwdriver. The knob can be adjusted by hand. It is important that all three of these controls be varied by equal amounts so that the klystron plates remain parallel.

Warning: Extremely high voltage appears at the klystron reflector cap.

(13) To increase the klystron frequency, turn the tuning screws and the knurled knob one-fourth turn clockwise.

(14) Place the KLYSTRON HV switch in the ON position and maximize the KLYSTRON POWER OUT meter reading with the REFL VOLTS ADJUST knob. Recheck the frequency of the klystron with the wavemeter and the indication as described in (10) and (11) above.

Caution: To prevent tube damage, each of the tuning screws should be advanced in turn and no more than one-half turn at a time.

(15) Repeat the procedures in (13) and (14) above as many times as necessary until the desired frequency is reached (within 5-wavemeter divisions).

(16) To lower the klystron frequency, turn the KLYSTRON HV switch to the OFF position. Use a screwdriver and turn both small screws on the front of the klystron counterclockwise one-fourth turn. By hand, turn the knob of the klystron motor counterclockwise one-fourth turn.

(17) Place the KLYSTRON HV switch to the ON position and maximize the KLYSTRON POWER OUT meter reading. Use the REFL VOLTS ADJUST knob and recheck the frequency of the klystron. Use the wavemeter and indication as described in (10) and (11) above.

(18) Repeat the procedures given in (16) and (17) above as many times as necessary until the desired frequency is reached (within 5-wavemeter divisions).

(19) Turn the left hand meter selector switch to PA CATH CUR. position and the right hand selector switch to PA GRID CUR. position.

Caution: Before proceeding to the next step in which the PLATE TUNING plunger is adjusted for the proper channel, loosen the LOCK thumbscrew and gently move the output-probe carriage to the right. Note that when properly tuned, the plate plunger fingers and output-probe are separated adequately and should not make contact. During the adjustment procedure, however, the output probe accidentally may be run into the plunger and damage it unless the output-probe carriage is adjusted carefully. Consequently, any output-probe carriage adjustment should be made very slowly and gently.

(20) Set the CATHODE TUNING cavity plunger (left hand ring) and PLATE TUNING cavity (right hand ring) to the positions indicated by pointers on CHANNEL TUNING indicator mounted on the power amplifier assembly.

(21) Tune the CATHODE TUNING cavity plunger for maximum PA GRID CUR. reading (METER B).

(22) Adjust the SLUG TUNER for maximum PA GRID CUR. reading. Initially this is done as follows:

  (*a*) After loosening the thumbscrew, vary one of the sliding controls up and down for maximum PA GRID CUR. reading.

  (*b*) Vary the other sliding control for maximum PA GRID CUR. reading.

  (*c*) Keep the spacing between the two controls fixed and slide both controls simultaneously up and down as far as possible; note the PA GRID CUR. meter reading. The meter reading should indicate two maximum readings. Set the controls at the point that provides the larger maximum PA GRID CUR. meter reading.

(*d*) Repeat the procedures given in (*a*) and (*b*) above.

(23) Repeat the procedures given in (21) and (22) above several times until the maximum possible readings on both meters are obtained.

(24) Recheck the klystron frequency as described in (9), (10), and (11) above. If the klystron frequency has shifted, readjust the frequency as described in (12) to (18) above.

(25) Turn the probe injection control on top of the power amplifier assembly counterclockwise (looking from the top) as much as possible without forcing, then turn the knob clockwise 3 turns.

(26) Place the PA PLATE breaker (in the high-voltage power supply) in the ON position and turn the VARIABLE AUTOTRANSFORMER knob until a reading of 70 is obtained on METER A with its selector switch in the PA CATH CUR. position.

(27) Turn the right hand selector switch to the PA POWER OUT position and move the output-probe carriage for maximum meter reading, then move it to the left about 1 inch.

(28) Repeat the procedures given in (21) and (24) above.

(29) Tune the PLATE TUNING cavity plunger (right hand ring) for maximum PA POWER OUT reading.

(30) Repeat the procedures given in (21) through (24) and (29) above.

(31) Check the reading of the LINE VOLTS meter on the radio transmitter. If this meter does not read 115 volts, vary the INCREASE OUTPUT control on the autotransformer for a reading as close as possible to 115 volts.

(32) Adjust the VARIABLE AUTOTRANSFORMER knob on the high-voltage power supply to a PA CATH CUR. reading of 100.

(33) Move the power amplifier probe carriage back and forth until the position giving maximum PA POWER OUT reading is found. Lock it in this position.

(34) Turn the left hand meter selector switch to AFC CORRECTION+ position. The meter reading should be approximately zero within two divisions. If it is not, rotate the smaller knurled knob on klystron-motor coupling assembly until the meter reading goes through zero. Rotate the knob until the meter reading returns to zero.

(35) Depress the MANUAL switch on the radio transmitter towards INCREASE or DECREASE (whichever position results in bringing the white detent indicator on the klystron-motor coupling assembly to the top). When the white and red parallel lines line up, release the switch.

(36) Engage the clutch by turning the large knob of the klystron-motor coupling assembly clockwise until the clutch is tight.

(37) Place the AFC switch on the radio transmitter to the ON position.

(38) Recheck the klystron frequency as indicated in (10) and (11) above. The desired frequency (within 5 mc) should be indicated by the wavemeter.

Note. Place the left hand meter selector switch on the PA CATH CUR. position. This meter should be observed after each of the steps indicated in the following subparagraphs to make sure that it does not exceed 100. If reading does exceed 100 at any time, adjust the VARIABLE AUTOTRANSFORMER knob for a reading of 100.

(39) Allow time for afc correction after each adjustment in the following steps: Readjust the SLUG TUNER and the CATHODE TUNING plunger ring for maximum PA GRID CUR. reading, and the PLATE TUNING plunger ring and power amplifier output-probe carriage for maximum PA POWER OUT indication.

(40) Turn the lock knob on the output-probe carriage clockwise until it is fingertight and the output-probe carriage is locked in position. Repeat the procedure given in (32) above.

(41) Turn VTVM SEL SW switch on the radio transmitter to the MON OUT position and the MOD INPUT SEL SW switch to the ST position.

(42) Adjust the ST LEVEL control on the radio transmitter for a PEAK VTVM meter reading of 100 (percent modulation scale) with its switch set to the NEG PEAK position.

Note. Positive peak readings will be about 22 percent lower and should not be used for these adjustments.

(43) Readjust the SLUG TUNER and CATHODE TUNING plunger ring for a maximum PA GRID CUR. reading.

(44) Turn the output-probe injection knob one-half turn in the direction that tends to increase the PA POWER OUT reading and adjust the PLATE TUNING plunger ring for a maximum METER B indication.

(45) Repeat the procedure given in (44) above as many times as required until the PA POWER OUT reading reaches a maximum, and further rotation of the probe injection knob and the retuning of PLATE TUNING plunger ring result in a reduced reading.

(46) Repeat procedures given in (32), (21), (22), and (44) above.

(47) Turn the power amplifier probe injection knob clockwise until the PA POWER OUT reading drops approximately 5 percent. Readjust the PLATE TUNING plunger ring for maximum PA POWER OUT reading.

(48) Readjust the ST LEVEL control for a PEAK VTVM meter reading NEG PEAK 140 percent modulation (70 on black scale).

(49) Turn the REFL VOLTS ADJUST knob approximately one-fourth turn clockwise. Allow the AFC motor to recorrect the frequency and note the PEAK VTVM meter reading.

(50) If the meter reading is decreased after AFC correction, repeat the procedure given in (49) above as many times as required to obtain a minimum PEAK VTVM reading. If the meter reading increased after the AFC correction indicated in (49) above, turn the knob counterclockwise and note the meter reading after correction. If the meter reading has decreased, continue to rotate the knob counterclockwise in one-fourth turn steps until the minimum PEAK VTVM reading is obtained.

(51) Repeat the procedures indicated in (48), (50), and (32) above twice.

78. Procedure for Adjustment of Order-Wire Transmitter T–389/TRC–29

a. Application of Power. To apply power to the order-wire transmitter, all switches on the high-voltage power supply and the POWER switch in radio transmitter must be in the ON positions. To apply power to the order-wire transmitter, proceed as follows:

(1) Place the order-wire transmitter FIL switch in the ON position.

(2) Place the order-wire transmitter PLATE switch in the ON position. Allow the unit to warm up for 5 minutes.

(3) Check the LINE VOLTS meter reading on the radio transmitter. It should be 115 volts. If it is not, readjust the INCREASE OUTPUT control on the autotransformer for a reading as close as possible to 115 volts.

(4) Place the front panel meter switch in the + 140-V position. The meter reading should be between 90 and 110.

b. Adjustment of Order Wire Transmitter T–389/TRC–29. The order-wire transmitter is adjusted in the following manner:

(1) Turn the front panel meter selector switch to the AUDIO position.

(2) Turn the ORDER WIRE TEST SWITCH to the THRU TONE position and adjust the AUDIO LEVEL THRU CHAN control for a reading of 100 on the meter.

(3) Turn the ORDER WIRE TEST SWITCH to the LOCAL TONE position and adjust the AUDIO LEVEL LOCAL INPUT control for a reading of 100 on the meter.

(4) Place the ORDER WIRE CARR LEVEL control in the extreme counterclockwise position. In the radio transmitter, adjust the ST LEVEL control for a PEAK VTVM reading of 100 percent with the switch in the NEG PEAK position. The MOD INPUT SEL SW should be in the ST position and the VTVM SEL SW in the MON OUT position.

Note. Positive peak readings will be about 22 percent lower and should not be used for these adjustments.

(5) Turn the VTVM SEL SW to the MOD OUT position and note the PEAK VTVM meter reading on the peak volts scale (black).

(6) Adjust the ORDER WIRE CARR LEVEL control in the order-wire transmitter clockwise until the reading on the PEAK VTVM meter increases by 20 percent over that noted in (5) above.

(7) At this point, with the radio and order-wire transmitter operating, the TRANSMITTER OPERATING lamp on the radio transmitter should go on. If it does not, adjust the MON OW PLATE TUN control on the radio transmitter (vtvm subchassis) until it does.

79. Tuning and Receiving Equipment

a. General. The receiving equipment is tuned and adjusted in accordance with the procedures given in paragraphs 80 through 84.

b. Control Settings in Radio Receiver. The external Radio Receiver R–418/G control settings should be as indicated in the chart in paragraph 74. The internal control settings should be as indicated below (fig. 104).

Control	Setting
REFL V	Midrange.
AFC switch	OFF.
IF. LEVEL	Maximum clockwise.
Mechanical tuning of preselector.	Tuning pistons should be run completely up and into the preselector cavities by means of large knurled screw at bottom of tuning carriage.

80. Procedure for Tuning Receiver Crystal Multiplier Chain

a. Application of Power. To tune the receiver crystal multiplier chain, it is only necessary to apply the low-voltage dc power to the receiver. The high-voltage power *should not* be applied to the receiver at this time. The following procedure should be used to apply the low-voltage power to the receiver:

(1) Be sure that all protective dust covers on the rear of the receiver rack are securely in place, and that the SERVICE SELECTOR SWITCH in the order-wire receiver is in the NORMAL position.

(2) Place the POWER switch in the radio receiver in the ON position. The POWER ON lamp on the receiver power supply should light. (It is assumed that the INPUT POWER BREAKER in the rear of the high-voltage power supply is ON.)

(3) Place the HV FIL switch in the receiver power supply in the ON position.

(4) Place the order-wire receiver FIL switch in the ON position. Allow the equipment to warm up for one-half hour.

(5) Check the LINE VOLTS reading on the radio transmitter. If it is not 115 volts, readjust the INCREASE OUTPUT control on the autotransformer for a reading as close as possible to 115 volts.

(6) Place the LV PL switch in the receiver power supply in the ON position. The PLATE ON lamp should light. Allow the equipment to warm up for 5 minutes.

(7) Repeat the procedure given in (5) above.

(8) Place the right hand meter selector switch on the radio receiver in the +250-V position. The meter reading should be between 95 and 110.

(9) Place the right hand meter selector switch on the radio receiver in the +150-V position. The meter reading should be between 95 and 110.

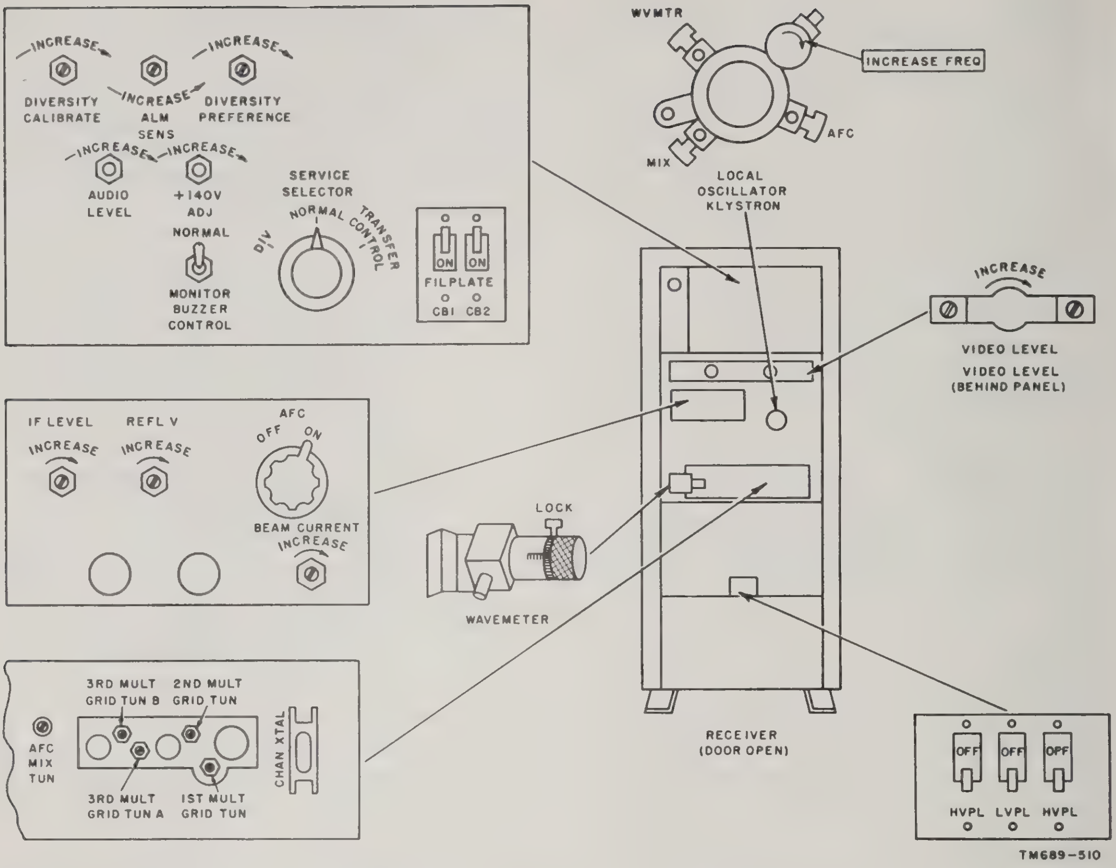

INCREASE
INCREASE
INCREASE
DIVERSITY CALIBRATE
ALM SENS
DIVERSITY PREFERENCE
INCREASE
INCREASE
AUDIO LEVEL
+140V ADJ
NORMAL
MONITOR BUZZER CONTROL
SERVICE SELECTOR
NORMAL
DIV
TRANSFER CONTROL
ON
ON
FIL
PLATE
CB1
CB2
WVMTR
INCREASE FREQ
AFC
MIX
LOCAL OSCILLATOR KLYSTRON
INCREASE
VIDEO LEVEL
VIDEO LEVEL (BEHIND PANEL)
IF LEVEL
REFL V
INCREASE
INCREASE
AFC
OFF
ON
BEAM CURRENT
INCREASE
LOCK
WAVEMETER
3RD MULT GRID TUN B
2ND MULT GRID TUN
AFC MIX TUN
CHAN XTAL
3RD MULT GRID TUN A
1ST MULT GRID TUN
RECEIVER (DOOR OPEN)
OFF
OFF
OFF
HVPL
LVPL
HVPL
TM689-510

Figure 104. Internal controls of Radio Receiver R–418/G.

b. Tuning Procedure. This tuning procedure given below can be used whenever the receiver crystal multiplier channel must be tuned. It is assumed that only the low-voltage power is applied to the receiver as described above. In addition, the AFC switch must be in the OFF position. The receiver crystal multiplier chain is tuned as follows:

(1) A 10-minute warmup period should be allowed before making any of the adjustments described below.

(2) Set the right hand meter selector switch to the AFC 1ST MULT GRID position. With the tuning tool provided on the right side wall of the receiver chassis, adjust the coil slug OSC MULT GRID TUN for maximum reading on METER B. This reading normally should be about 50 for a properly tuned crystal.

Note. A reading lower than this usually indicates a faulty crystal, poor tube, or improper alinement. If a more careful realinement does not increase the meter reading sufficiently, refer to the equipment performance check list (par. 132) to aid in locating and repairing trouble.

(3) Set the left hand meter selector switch to the 2ND MULT GRID position. Adjust coil slug 2ND MULT GRID TUN for a maximum reading on METER A. This reading should be more than 50.

(4) Set the right hand meter selector switch to the 3RD MULT GRID position. Adjust the 3RD MULT GRID TUN A coil slug and then the 3RD

MULT GRID TUN B coil slug for maximum reading on METER B.

(5) Repeat the procedure given in (4) above. A meter reading of more than 30 should be obtained.

(6) Set the left hand meter selector switch to AFC MIXER position. Adjust the AFC MIX TUN trimmer capacitor for a maximum reading on METER A. This reading should be more than 30.

(7) Repeat the procedures given in (2) and (3) above.

81. Procedure for Coarse Tuning of Klystron

a. General. The frequency of the receiver klystron is tuned to any desired frequency in the 1,700- to 2,520-mc range in accordance with the procedure outlined below. The klystron is used at two frequencies (pars. 82 and 83). The first is the channel *carrier* frequency for tuning the preselector. The second is the intended *local-oscillator* frequency, which is 120 mc above the carrier frequency. The klystron can be adjusted to within 5 mc of either of these frequencies in the manner described below.

b. Application of Power. In the following procedure, it is assumed that low-voltage power has been turned on as described in paragraph 80 and that the AFC switch is in the OFF position. Proceed to apply high-voltage power to the receiver as follows:

(1) Place the HV PL switch in the receiver power supply to the ON position.

(2) Place the left hand meter selector switch to the BEAM V position. The meter reading should be between 90 and 100 volts.

(3) Check the LINE VOLTS meter reading. If it is not 115 volts, readjust the INCREASE OUTPUT control on the autotransformer for a meter reading as close as possible to 115.

c. Adjustment Procedure. The receiver klystron frequency is adjusted in accordance with the following procedure:

(1) Place the right hand meter selector switch to the IF. MIXER position. Adjust the REFL V control for a maximum reading on METER B.

(2) Switch the left hand meter selector switch to the WAVEMETER position. Tune the wavemeter until the METER A reading is maximum.

(3) Note the reading of the wavemeter calibrated scale at the marker. Use the calibration chart mounted on the back of the receiver door to determine the operating frequency of the klystron.

(4) Generally, the klystron frequency will not be at the desired frequency. Determine the difference between the actual and desired frequencies.

(5) The klystron frequency is increased by turning the INCREASE FREQ mechanical tuning knob (at upper right of the local-oscillator assembly) clockwise, and is decreased by turning this knob counterclockwise. The tuning sensitivity of this control is about 36 mc per turn. Turn the knob in the direction and by an amount that will approximately bring the klystron to the desired frequency.

(6) Repeat the procedures given in (1), (2), (3), and (5) above until a frequency within 5 mc of the desired frequency is obtained.

(7) Readjust the REFL V control for a maximum IF. MIXER reading on METER B. If the meter reads off scale, loosen the setscrew on the local-oscillator output connector labeled MIXER and withdraw the injection probe until the meter reading is on scale. Lock the probe at this setting by tightening the setscrew.

(8) Set the wavemeter to a setting that corresponds to the desired frequency. Adjust the klystron INCREASE FREQ control for a maximum reading on METER A with the selector switch in the WAVEMETER position. If the meter reading goes off scale, loosen the setscrew on the local-oscillator output connector labeled WVMT and withdraw the probe for a meter reading of about 50.

82. Procedure for Coarse Tuning Preselector

a. General. In the initial installation of the radio set, and in some conditions subsequent to the initial installation where a microwave carrier signal is not available from the previous station, the preselector must be tuned in two stages:

(1) Coarse tuning of the preselector where the local oscillator in the radio receiver is used as a source of the microwave carrier.

(2) Fine tuning of the preselector when a microwave carrier is available from previous station. The procedure for fine tuning of the preselector is described in paragraph 91.

b. Coarse Tuning Procedure. The preselector is adjusted as follows:

(1) Adjust the klystron to the carrier channel frequency in accordance with the procedure outline in paragraph 81.

(2) Disconnect the receiver RF INPUT cable connected to the duplexer.

(3) Check to see that the two shorting plungers on the primary and secondary preselector cavities are down. Set the vernier tuning screw directly below the primary cavity (under RF INPUT connection) plunger to the middle of its range.

(4) Connect the 20-db RG–21A/U cable stored at the rear of the radio transmitter to the receiver rf cable disconnected ((2) above). This cable provides the preselector primary with a 50-ohm termination.

(5) Place the right hand meter selector switch to the IF. MIXER position.

(6) Place the primary shorting plunger in its upper position. Adjust the preselector carriage TUNING control (large knurled knob below and to the right of the tuning pistons) through its entire range, noting the METER B reading. Adjust the TUNING control for a dip.

(7) Place the primary shorting plunger to its lower position. Adjust the vernier tuning screw for a maximum reading on METER B.

(8) Disconnect the 20-db RG–21A/U cable from the duplexer and replace it on rear of the radio transmitter.

(9) Reconnect the receiver rf cable to the duplexer.

83. Procedure for Fine Tuning of Local Oscillator

The frequency of the local oscillator is adjusted in accordance with the following procedure:

a. Adjust the klystron to the local-oscillator frequency (120 mc above the carrier frequency) in accordance with the procedure outlined in paragraph 81.

Note. AFC switch should be in the OFF position.

b. Set the left hand meter selector switch to AFC CORRECTION+ position. Turn the mechanical INCREASE FREQ tuning knob so that meter reading swings from a positive indication to zero and then to a negative indication. (If a meter reading is not obtained, the AFC pickup loop must be adjusted as described in *e* below.) The tuning knob should be set for a zero reading that is obtained as the meter reading swings from one polarity to the other.

c. Place the right hand meter selector switch in the IF. MIXER position. Note both the METER A and METER B (AFC CORRECTION+) readings as the REFL V control is varied. The IF. MIXER meter reading should be maximum when the AFC CORRECTION+ meter reading is zero. If it is not, readjust the INCREASE FREQ tuning knob and REFL V control until this coincidence is obtained.

d. Loosen the setscrew on the local-oscillator output connection labeled MIX and withdraw the pickup probe until an IF. MIXER meter reading of 65 is obtained. Lock the probe in this position by tightening the setscrew (thumb-tight) and repeat the procedures given in *b* above.

e. Set the right hand meter selector switch to AFC IF. LEVEL position. Loosen the setscrew on the local-oscillator output connector labeled AFC and rotate the pickup loop for a meter reading of 55. Lock the probe in this position and repeat the procedures given in *b* above.

f. Turn the AFC switch from the OFF to the ON position. Check to see that the IF. MIXER reading is 65. Switch the left hand meter selector switch between the AFC CORRECTION+ and AFC CORRECTION— positions. If these readings vary by more than five divisions, or if an IF. MIXER reading of 65 is not obtained, repeat the procedures given in *b*, *c*, and *d* above as many times as necessary to obtain these readings.

84. Procedure for Adjustment of Order-Wire Receiver R–543/TRC–29

a. Application of Power. To apply power to Order-Wire Receiver R–543/TRC–29, follow the procedure in (1) through (3) below. (It is assumed that the POWER switch on the radio receiver and all switches on receiver power supply have been placed in ON position.)

(1) Place the FIL switch in the order-wire receiver in the ON position.

(2) Place the PLATE switch in the order-wire receiver in the ON position. The RECEIVER ON lamp should come on.

Note. Make certain that the SERVICE SELECTOR switch is in the NORMAL position.

(3) Place the meter switch in +140V position. The meter reading should be between 90 and 110.

b. Adjustment of Order Wire Receiver R–543/TRC–29. The order-wire receiver is adjusted in the following manner:

(1) Disconnect cable CG–409C/U (1 ft 7 in.) from the VIDEO INPUT FROM REC jack at the rear of the order-wire receiver.

(2) Disconnect cable CG–409C/U (2 ft 6 in.) from OW CARR INPUT jack at the rear of the radio transmitter and and connect it to VIDEO INPUT FROM REC jack at the rear of the order-wire receiver. Set the ORDER WIRE TEST SWITCH to the THRU TONE position.

(3) Set the front panel meter selector switch to the AUDIO position. Adjust the AUDIO LEVEL control for a reading of 100 on the front panel meter.

(4) Set the order-wire transmitter ORDER WIRE TEST SWITCH to the OPR position.

(5) Reconnect the cables that were disconnected in the procedures given in (1) and (2) above to their respective jacks.

(6) Disconnect cable CG–409C/U (1 ft 7 in.) between the receiver VIDEO OUTPUT TO ORDER WIRE REC jack and the order-wire receiver VIDEO INPUT FROM REC jack.

(7) Set the order wire receiver BUZZER CONTROL switch to the NORMAL position. Adjust the ALM SENS potentiometer completely counterclockwise. The alarm buzzer should be off. Readjust the ALM SENS control slowly clockwise until the buzzer sounds.

(8) Reconnect the cable between VIDEO OUTPUT TO ORDER WIRE REC jack and VIDEO INPUT FROM REC jack. Place the BUZZER CONTROL switch in the MONITOR position.

Section VI. ADJUSTMENT OF EQUIPMENT ON SINGLE-HOP BASIS

85. Adjustments of Section

At this point the radio set at each station has been tuned to the desired channel frequencies and the order-wire channel adjusted. It is now possible to establish communications between stations and make necessary adjustments on a single-hop basis, for example, station-to-station basis. These adjustments include:

a. Orientation of antennas for maximum signal.

b. Fine tuning of preselector.

c. Check for adequate signal.

d. Adjustment for diversity reception, when diversity is used.

Note. Refer to paragraphs 65 through 72 for the location and illustration of all controls; refer to paragraph 54 for the location and function of all receptacles.

86. Connection of Order-Wire Channel

a. Some of the procedures given in this section involve adjustments that are made at two stations. For convenience, one of these stations is designated as station No. 1 and the other as station No. 2. The designation of these numbers is completely arbitrary. It does not matter which station is designated as No. 1 or No. 2.

b. To make adjustments on a station-to-station basis, it is usually convenient to establish order-wire communications between personnel located at the following points:

(1) At station No. 1 antenna.

(2) At station No. 1 receiver.
(3) At station No. 2 antenna.
(4) At station No. 2 receiver.

c. To establish communication between these four points, proceed as follows:

(1) At each station, both terminal and repeater, at least two handsets are supplied with Handset-Signaling Unit H–102/TRC–29. One of these handsets should be used for local operation at the receiver and the other for remote operation at the antenna.

(2) To connect the handset locally, the handset cable is run into the hole to the right of the RING button and connection is made to the three posts on the terminal marked HANDSET CONN. Connection to these posts is made as follows:

(*a*) The white lead is connected to the post marked R.
(*b*) The red lead is connected to the post marked C.
(*c*) The black lead is connected to the post marked T.

(3) To operate the handset remotely, the handset cable is connected to the three posts in the HANDSET CONN terminal on the Handset-Signaling Unit H–102/TRC–29 (remote handset). The white, red, and black leads are connected to the R, C, and T posts, respectively. Two pairs of standard telephone wires, such as field Wire WD–1/TT, not exceeding about 250 feet in length, should be connected between terminals on the remote handset and terminals on the rear of the order-wire receiver as follows:

(*a*) One wire between terminals marked GND.
(*b*) One wire between terminals marked XMTR.
(*c*) One wire between terminals marked REC.
(*d*) One wire between terminals marked RING.

87. Operation of Order-Wire Channel

Communication can be maintained (after antenna is oriented) between any and all handsets on a party line basis, so that it is possible to transmit and receive simultaneously on all handsets. The following procedure is used for the operation of the order-wire channel:

a. To transmit, depress the push-to-talk control and talk into the transmitter.

b. To receive, place the receiver portion of the handset to the ear.

c. To ring, press the RING button on the order-wire receiver or the ring button on the side of the remote handset for local operation. The button should be depressed for about 1 second, released, and pressed again for 1 second, released, as many times as necessary. Note that if the ring button is depressed for more than 1 second, the ringing will stop about 1 second. To ring again, it is necessary to release the button and press it again.

88. Preliminary Antenna Orientation on Two-Way Links With Single Antenna

After the telephone handsets have been connected, try to establish communication between the two stations. If successful, the preliminary orientation procedure given below can be omitted. Refer to paragraph 90 on antenna orientation. If not successful, proceed as follows:

a. At the prearranged starting time the personnel at station No. 1 and those at station No. 2 proceed to rotate both antennas at the same time.

b. At station No. 1, the antenna should be placed in its extreme counterclockwise position and rotated clockwise at a very slow rate so that the antenna is turned from one extreme position to the other in about 10 minutes.

c. At station No. 2, the antenna should be turned clockwise from its extreme counterclockwise position at a rate that turns it from one extreme position to the other and returns it in about three-fourths of a minute. This antenna should be rotated back and forth at this rate.

d. The operator located at the receiver of station No. 1 should continuously transmit a signal over the order-wire channel. All other attendants (at the two antennas and station No. 2 receiver) should listen for this signal.

e. This procedure should be continued until communications are established between the two stations; that is, until the signal originating at station No. 1 is heard at station No. 2.

Note. One-way links and four-antenna links can be established faster and simpler if two-way vhf communication can be used until antennas are oriented.

89. Preliminary Antenna Orientation on Two-Way Links Using Separate Antennas without Duplexers

After the telephone handsets have been connected, an attempt should be made to establish communication between the two stations. If communication cannot be established, proceed as follows:

a. When permitted by frequency allocation or by temporary operation on a noninterference basis, connect the duplexer into the circuit and use suitable installation facilities to permit use of the duplexer. To aline the antennas, follow the procedure outlined in paragraph 88. Remove the duplexers and retune the equipment to permanently authorized frequencies and connect it to the correct transmitting and receiving antennas.

b. When it is necessary to operate only on the permanently assigned frequencies, proceed as follows:

(1) At station No. 1, both the transmitter and the receiver should be operating. The transmitting antenna should be rotated at a slow rate (10 minutes) while the receiving antenna should be rotated at the fast rate (¾ min.).

(2) At station No. 2, only the receiver should be operating. The transmitter should be turned off (the POWER switch on the radio transmitter in the OFF position). The receiving antenna should be rotated at a fast rate.

(3) When a signal is received at station No. 2, indicating that the receiving antenna is oriented properly, the transmitter should be turned on immediately and the transmitting antenna oriented in the same position as the receiving antenna.

(4) As soon as the station No. 2 signal is received by station No. 1, the receiving antenna rotation should be stopped and the transmitting antenna oriented in the same direction. It should now be possible to establish two-way communications.

90. Final Antenna Orientation Procedure After Signal Is Received

a. Two-Way Installations Using Duplexer and Single Antenna. At installations using a duplexer, the antennas are oriented as follows:

(1) At station No. 1, place the receiver left hand selector switch at the IF. LEVEL position.

(2) The operator at station No. 1 receiver should direct the operator at station No. 1 antenna over the order-wire channel to rotate the antenna, first vertically, then horizontally, for a maximum IF. LEVEL meter reading. Lock the antenna in this position.

(3) At station No. 2, repeat the procedures given in (1) and (2) above, reversing the station numbers.

b. Four-Antenna Installations Without Duplexer. At installations without duplexers or one-way links, the antenna is oriented as follows:

(1) At station No. 1, place the left hand meter selector switch at the IF. LEVEL position.

(2) The operator at station No. 1 receiver should then direct the operator at station No. 2 antenna, over the order-wire channel, to rotate the transmitting antenna, first vertically, then horizontally, for a maximum IF. LEVEL meter reading.

(3) The operator at station No. 1 receiver should direct the operator at station No. 1 antenna to rotate the receiving antenna, first vertically, then horizontally, for a maximum IF. LEVEL meter reading.

(4) Repeat the procedures given in (2) and (3) above. This orients the antennas of station No. 2 to station No. 1 path.

(5) Repeat the procedures given in (1) to (4) above, reversing the station numbers so that the path antennas of station No. 1 to station No. 2 are oriented.

91. Fine Tuning of Preselector

The preselector should be tuned at each station to provide a maximum IF. LEVEL meter reading. With IF. LEVEL maximum clockwise, proceed as follows:

a. Detune the preselector primary by moving the shorting plunger to its upper position. Adjust the preselector carriage TUNING control for maximum reading on METER A with switch in IF. LEVEL position.

Note. If the buzzer sounds, place the BUZZER CONTROL switch in the NORMAL position.

b. Return the preselector primary shorting plunger to its lower position.

c. Detune the preselector secondary (rear cavity in preselector assembly) by moving the shorting plunger to its upper position. Adjust the venier tuning screw just below the *primary* shorting plunger for a maximum IF. LEVEL meter reading. Return shorting plunger to its original position.

d. Repeat the procedures given in *a* to *c* above until there is no evidence of one adjustment affecting the peaking of the other. Drop both shorting plungers to their lower position.

e. Adjust IF. LEVEL control maximum counterclockwise (minimum IF. LEVEL reading on meter).

f. Note the minimum reading of IF. LEVEL on the meter.

(1) If the reading is less than 60, adjust the IF. LEVEL control clockwise until the reading is 70.

(2) If the reading is greater than 60, adjust IF. LEVEL control clockwise for a reading 10 divisions greater than minimum reading obtained.

g. Connect the spare set as an operating set as described in paragraph 64 and tune its preselector in the manner described in *a* to *f* above.

92. Check for Adequate Signal

The equipment now is properly tuned to operate on a single-hop basis. The next step is to make sure that an adequate signal is being picked up by the radio receiver. This is done as follows:

a. Disconnect cable CX–2683/U (3 ft 1 in.) between the RF OUTPUT jack at the rear of the radio transmitter and the transmitter jack on the duplexer at both ends.

b. Disconnect the receiver rf cable from the receiver jack on the duplexer and connect it to the ANTENNA ADAPTER at the rear of the radio receiver.

c. Connect one end of cable CX–2683/U (3 ft 1 in.), which was disconnected in the procedures given in *a* above, to the bottom end (to the left of VIDEO INPUT jack on radio transmitter) of the 20-db RG–21/U cable stored at the rear of radio transmitter. Connect the other end to the receiver jack on the duplexer.

d. Pry the top end of the 20-db RG–21/U cable loose from its retaining clips and connect it to the ANT. connector at the rear of the radio receiver. This effectively inserts 20-db loss between the duplexer receiver output and the receiver input.

e. Place the left hand meter selector switch in the radio receiver to the IF. LEVEL position. Note the METER A reading. (On strong signal paths a more precise preselector tuning may be obtained by repeating the preselecting tuning procedure of paragraph 91.) Connect all cables as they were originally.

f. If the meter reading (*e* above) is not greater than 50, the orientation of the antennas and the tuning of the transmitter and receiver should be checked in accordance with the procedures outlined in this and the preceding section. If it is determined that the antennas are oriented properly and that the equipment is tuned properly, the topography of the path should be investigated carefully to make sure that line-of-sight clearance is being obtained. Sometimes, it may be necessary to cut down tall trees in the areas surrounding the sites.

g. A signal providing a meter reading of 50 is marginal and when possible a higher tower should be used to increase the signal strength.

93. Adjustment and Check of Receivers for Diversity Operation

a. Procedure. In installations employing diversity reception, the two receiving equipments are tuned, adjusted, and their antennas oriented on an individual basis following the procedures given in this and the preceding section. The receivers now can be adjusted to provide proper diversity operation in accordance with the procedure outlined in this paragraph.

b. Interconnections for Adjustment. The two receivers normally are connected for diversity operation in accordance with the procedure given in paragraph 62. However, to make the adjustments described in this paragraph, these interconnections must be modified as follows:

(1) Disconnect cable CG–409C/U (1 ft 7 in.) from the receiver VIDEO OUTPUT TO ORDER WIRE REC jack and the order-wire receiver VIDEO INPUT FROM REC jack in both preferred and standby receivers. One of the receivers is called the preferred receiver, and the other is known as the standby receiver (par. 62).

(2) Connect a type UG–274/U BNC T-connector to the VIDEO OUTPUT TO ORDER WIRE REC jack on the preferred receiver.

(3) Connect cable CG–409C/U (1 ft 7 in.) between the preferred order-wire receiver VIDEO INPUT FROM REC jack and one end of the T-connector. Refer to (2) below.

(4) Disconnect cable CG–409C/U (5 ft 1 in.), normally connected between the O.W. CARR FILTER OUTPUT jack and the VIDEO INPUT FROM DIV REC jack on the standby order-wire receiver, to the other end of the T-connector.

c. Setting of Controls. The controls in both order-wire receivers should be set as follows:

Control	Setting
SERVICE SELECTOR switch	DIV.
DIVERSITY PREFERENCE	Fully counterclockwise.
DIVERSITY CALIBRATE	Fully clockwise.
ALM SENS	Fully counterclockwise.
BUZZER CONTROL	MONITOR.
FIL	ON.
PLATE	ON.

d. Adjustment Procedure. Proceed to adjust the receivers as follows:

(1) In both order-wire receivers, disconnect the end of cable CG–409C/U (1 ft 7 in.) connected to the VIDEO INPUT FROM REC jacks. Set the preferred order-wire receiver front panel meter selector switch to DIV CONT LEVEL. A meter reading of approximately 70 should be obtained. Note the meter reading obtained on the order-wire receiver panel meter.

(2) Set the preferred order-wire receiver front panel meter selector switch to DIV OPR position. Adjust the DIVERSITY PREFERENCE control slowly clockwise until the diversity relay is energized, as indicated by a meter reading of approximately 100. Note the position of the control that gives this meter reading.

(3) Slowly adjust the DIVERSITY PREFERENCE control counterclockwise until the diversity relay relaxes (when the front panel meter reads zero). Note the position of the control.

(4) Set the DIVERSITY PREFERENCE control to a position midway between the positions noted in (2) and (3) above.

(5) Reconnect both cables to VIDEO INPUT FROM REC jacks.

(6) Disconnect the cable from the ANT. jack on preferred radio receiver.

(7) Place the front panel meter selector switch in the preferred order-wire receiver in DIV CON LEVEL position.

(8) Note the meter reading and compare it with the reading obtained in the procedure given in (1) above. If the reading is higher, adjust the DIVERSITY CALIBRATE control in the standby order-wire receiver until the meter reading is the same as that obtained in (1) above.

(9) If the reading obtained in (8) above is lower than that obtained in the procedure given in (1) above, adjust the DIVERSITY CALIBRATE control in the preferred order-wire receiver until the same meter reading is obtained.

e. Diversity Operation Check. To check the diversity operation, proceed as follows:

(1) Disconnect cable CG–409C/U (1 ft 7 in.) from the VIDEO INPUT FROM REC jack in the back of the preferred order-wire receiver.

(2) Note the DIV CONT LEVEL meter reading on the front panel of the preferred order-wire receiver. It should rise to a reading of approximately 150.

(3) Reconnect cable RG–58C/U to the pre-

ferred order-wire receiver VIDEO INPUT FROM REC jack.

(4) Disconnect the cable CG–409C/U (1 ft 7 in.) from the VIDEO INPUT FROM REC jack at the rear of stand by order-wire receiver.

(5) The DIV CONT LEVEL meter reading on the front panel of the preferred order-wire receiver should drop to approximately 35. Reconnect cable RG–58C/U.

f. Interconnection for Diversity Operation. Reconnect the equipment for diversity operation as described in paragraph 62.

g. Adjustment of Alarm Sensitivity. The alarm sensitivity control in the preferred order-wire receiver is adjusted as follows:

(1) Disconnect cable CG–409C/U (1 ft 6 in.) between the receiver VIDEO OUTPUT TO ORDER WIRE jack and the order-wire receiver VIDEO INPUT FROM REC jack at both receiving equipments.

(2) Set both order-wire receiver BUZZER CONTROL switches to NORMAL.

(3) Neither alarm buzzer should sound. Adjust each ALM SENS potentiometer clockwise until buzzer sounds.

(4) Reconnect the cables disconnected in the procedure given in (1) above. Buzzers should be silenced.

Section VII. RADIO RELAY SYSTEM ADJUSTMENT AND OPERATION

94. General

Previously, all radio link equipment used in the radio relay system has been tuned and adjusted on a single-hop basis as described in paragraphs 85 through 93. This section covers the procedures necessary to adjust the video levels in conjunction with the video equipment used in the system and an overall operational check of the radio relay system. Included in this section are the following:

a. Setting of controls for system operation.

b. Use of transmitter VTVM to measure receiver video output level.

c. Adjustment of video controls.

d. Recording of meter readings.

e. Measurement of system signal-to-noise ratio.

95. Setting of Controls for System Operation

The controls on each radio set should be set as indicated in the chart below. For location, illustration, and function of controls, refer to paragraphs 65 to 72.

Location of control	Control	Setting
Order Wire Transmitter T–389/TRC–29.	ORDER WIRE TEST SWITCH	OPR.
	Meter selector switch	AUDIO.
	TRANSFER CONTROL-MANUAL OPERATE	MANUAL OPERATE.
	FIL	ON.
	PLATE	ON.
Radio Transmitter T–303/G	POWER	ON.
	MOD INPUT SEL SW	VID.
	AFC	ON.
	VTVM SEL SW	MON OUT.
Power Supply PP–764/G	HV FILAMENT	ON.
	LV FILAMENT	ON.
	BIAS V −150V	ON.
	LV PLATE	ON.
	KLYSTRON HV	ON.
	PA PLATE	ON.
	PA PLATE VOLTAGE ADJUST-KLYSTRON BEAM VOLTAGE TEST ADJUST.	PA PLATE VOLTAGE ADJUST.
	INPUT POWER BREAKER	ON.

Location of control	Control	Setting
Order Wire Receiver R–543/TRC–29.	Meter selector switch	AUDIO.
	SERVICE SELECTOR	NORMAL (or DIV for diversity operation).
	BUZZER CONTROL	NORMAL.
	FIL	ON.
	PLATE	ON.
Radio Receiver R–418/G	POWER	ON.
	AFC	ON.
Power Supply PP–690/G	HV FIL	ON.
	LV PL	ON.
	HV PL	ON.

96. Use of Transmitter VTVM for Measurement of Receiver Video Level

a. General. A convenient method of measuring the receiver video output level is to use the PEAK VTVM meter in the radio transmitter. To use the VTVM for this purpose, it is necessary to make the cable connections indicated in *b* through *d* below.

b. Terminal Stations. At a terminal connection, a measurement is made in the following manner:

(1) Disconnect the cable from the VIDEO INPUT jack at the rear of the radio transmitter.

(2) Disconnect the cable from VIDEO OUTPUT jack at rear of order-wire receiver.

(3) Connect cable CG–409C/U (25 ft) from VIDEO INPUT jack of the radio transmitter to VIDEO OUTPUT jack of order-wire receiver.

(4) Place the radio transmitter MOD SEL SW to the GND position.

(5) Place the radio transmitter VTVM SEL SW to MOD IN position. The PEAK VTVM meter on the radio transmitter now measures the receiver video output level.

(6) After measurement is made, replace all cables to their original connections.

c. Through Repeaters. At through repeaters, the receiver video output normally is connected to the transmitter. Therefore, the receiver video level is measured by placing the VTVM SEL SW to the MOD IN position.

d. Drop-Channel Repeaters. At drop-channel repeaters, the procedure given in *b* above for terminal stations can be used.

97. Adjustment of Video Levels
(fig. 105)

a. General. The sequence of adjusting video levels usually is as follows:

(1) Adjust the video level of the video equipment feeding the east radio transmitter.

(2) Adjust the input video level of the east transmitter.

(3) Adjust the east-west receiver video level and then the east-west transmitter video input level at each repeater.

(4) Adjust the video level of the west receiver.

(5) Repeat the procedures in (1) through (4) above going from the west terminal to the east terminal. In each step, of course, the word west must be substituted for east, and vice versa.

(6) After all video levels have been adjusted in each station, the spare set should be placed into operation, as described in paragraph 64, and its video controls adjusted for the same readings as those obtained on the set it replaced. After the spare set is adjusted, the operating set should be placed back into operation and power should be turned off in the spare set by turning INPUT POWER BREAKER switches on the high-voltage power supply to the OFF position.

Figure 105. Order-wire and video-level controls.
(Contained in separate envelope)

b. Adjustment at Terminal. At a terminal, the video levels are adjusted in the following manner:

(1) *Video equipment.* When the video output level of the video equipment (terminal or repeater) can be varied, it should be adjusted to provide a PEAK VTVM meter reading of 40 on the PEAK VOLTS scale (black scale) with the POS PEAK-NEG PEAK selector switch set to the position giving the larger reading and the VTVM SEL SW in MOD IN position (fig. 106).

(2) *Radio receiver.* The radio receiver VIDEO LEVEL control is adjusted for a PEAK VTVM meter reading of 40 on the PEAK VOLTS scale (black scale) with the POS PEAK-NEG PEAK selector switch set to the position giving the larger reading and the VTVM SEL SW in the MOD IN position. (Refer to the procedure given in par. 96 for the procedure for measuring the receiver output.)

(3) *Radio transmitter.* The adjustment of the INPUT VIDEO LEVEL control in the transmitter modulator is a function of the type of modulation fed into the red scale of the PEAK VTVM meter with the POS PEAK-NEG PEAK selector switch set to the position giving the larger reading and the VTVM SEL SW in the MON OUT position. The adjustments for a ppm radio relay system, and a television relay system are given below.

Note. Be extremely careful not to confuse the INPUT VIDEO LEVEL control with the VIDEO LEVEL control on the afc if. transmitter. Generally, the INPUT VIDEO LEVEL is adjusted for 100 on the % MODULATION scale chassis for the modulator INPUT VIDEO LEVEL control.

(*a*) *Ppm radio relay system, 23 channel.* Adjust the INPUT VIDEO LEVEL control on the transmitter modulator for a reading of 100 on the % MODULATION scale (red scale) of the PEAK VTVM meter with the POS PEAK-NEG PEAK selector switch set to the position giving the larger reading and the VTVM SEL SW in the MON OUT position.

(*b*) *Ppm radio relay system, 45 channel.* Adjust the INPUT VIDEO LEVEL control on the transmitter modulator for a reading of 100 on the % MODULATION scale (red scale) of the PEAK VTVM meter with the POS PEAK-NEG PEAK switch in either position and the VTVM SEL SW in MON OUT position. Check the meter reading with the switch in POS PEAK and again in the NEG PEAK position. The two readings should be the same. If they are not, adjust the REFL VOLTS ADJUST control to obtain approximately equal readings in each position. Readjust the INPUT VIDEO LEVEL control for a reading of 100 percent (red scale).

(*c*) *Frequency-division modulation (or other sinusoidal modulation) radio relay system.* Adjust the INPUT VIDEO LEVEL control on the transmitter modulator for a reading of 100 on the % MODULATION scale (red scale) on the PEAK VTVM meter with the POS PEAK-NEG PEAK selector switch set to either the POS PEAK or the NEG PEAK position and the VTVM SEL SW in MON OUT position. Balance these readings as in (*b*) above.

(*d*) *Television radio relay system.* Adjust the INPUT VIDEO LEVEL control on the transmitter modulator chassis for a reading of 100 on the % MODULATION scale (red scale) of the PEAK VTVM meter with the POS PEAK-NEG PEAK switch set to the position giving the larger reading and the VTVM SEL SW in the MON OUT position. If the television circuit is not sending a test pattern and is handling moving material, the percent modulation value will vary with time. Set the controls so that the greatest observed signal, which may be either

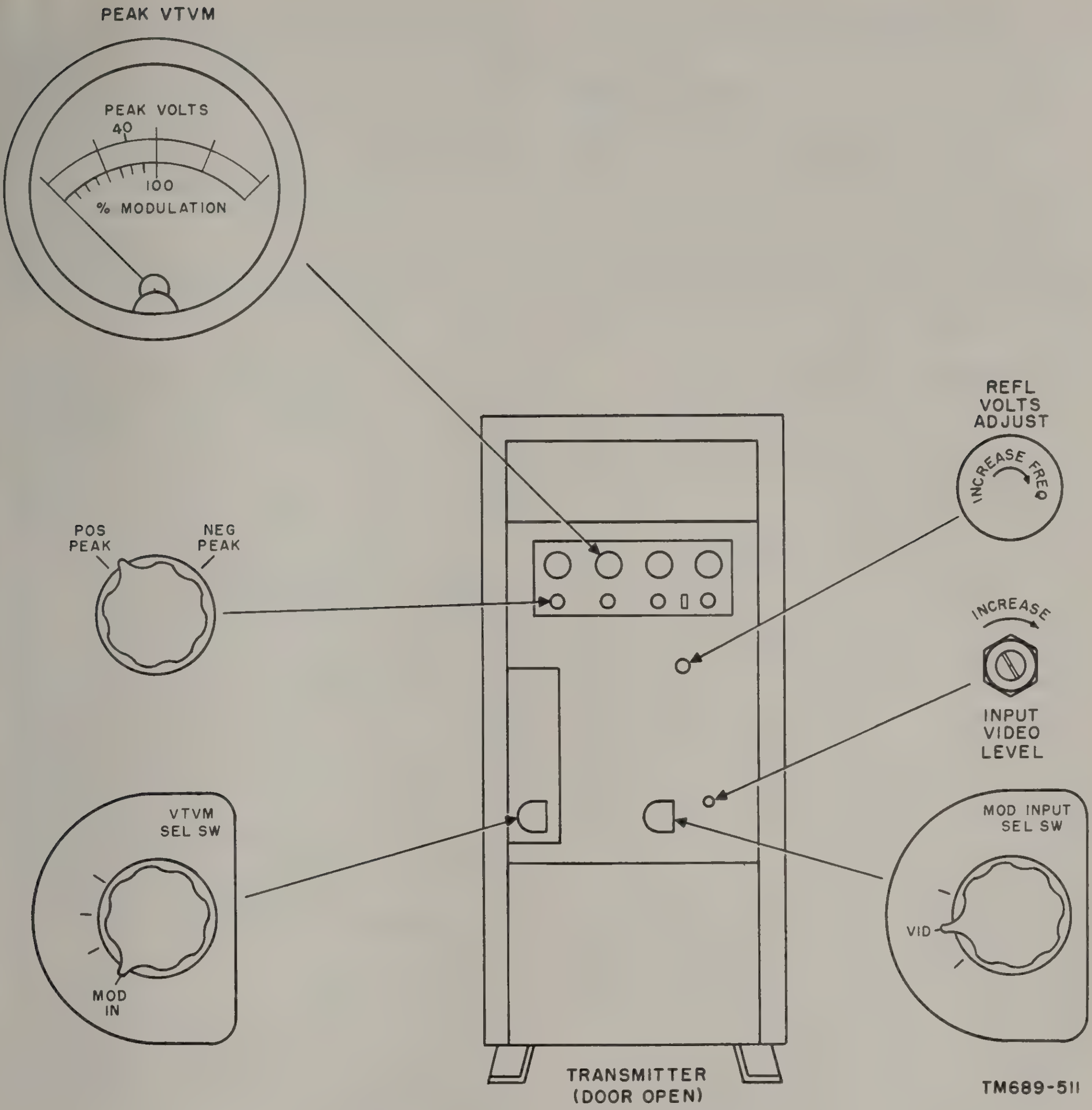

PEAK VTVM
PEAK VOLTS
40
100
% MODULATION
REFL VOLTS ADJUST
INCREASE FREQ
POS PEAK
NEG PEAK
INCREASE
INPUT VIDEO LEVEL
VTVM SEL SW
MOD IN
MOD INPUT SEL SW
VID
TRANSMITTER (DOOR OPEN)
TM689-511

Figure 106. Internal controls of transmitter.

positive or negative, is adjusted to 100. The relative polarity of an all-white and an all-black picture will reverse the POS PEAK-NEG PEAK position giving the greatest reading.

c. Adjustment of Through Repeaters. At through repeaters, the video is adjusted as follows:

(1) *Receiver video output.* The VIDEO LEVEL control in the radio receiver is adjusted as described in *b*(2) above.

Note. Do not use the receiver VIDEO LEVEL control to adjust the transmitter % MODULATION level at repeater stations. Use only the transmitter modulator chassis INPUT VIDEO LEVEL control as described below: receiver output levels lower than 40 on MOD IN position will reduce the level of the order-wire carrier to a level that will give a noisy or inoperative order-wire circuit (fig. 106).

(2) *Transmitter.* The INPUT VIDEO LEVEL control in the transmitter modulator chassis is adjusted as described in *b* (3) above.

d. Adjustment at Drop-Channel Repeaters. At drop-channel repeater stations, the drop-channel equipment (video equipment), the radio transmitters, and the radio receivers are adjusted as described in *b* (1), (2), and (3) above.

98. Adjustment of Audio Levels

a. The order-wire transmitter adjustments detailed in paragraph 78*b* and order-wire receiver adjustments detailed in 84*b* are adequate to permit through operation of the tandem connected order-wire circuits.

b. Since each link is adjusted for proper order-wire modulation on a single-hop basis from built-in tone oscillators whose levels can differ by 3 db, a through test tone may show an indicated level from 50 percent to 150 percent depending upon the relative difference in the built-in oscillator levels. This is normal operation since the four-wire connected order-wire circuits are designed to give proper operation within this range. The involved level-setting procedure required of two-wire circuits using hybrids is unnecessary.

Note. It should be noted that the local handset of the order-wire receiver *does not* have a means for adjusting the level of the received voice signal. The signal level has been chosen to give an adequate handset signal for noisy locations. The order-wire receiver AUDIO LEVEL control adjusts the through level as well as the local handset level (fig. 105). Too low a setting of the AUDIO LEVEL control can prevent through talking on the order-wire channel.

c. When the local handset level must be adjusted for other than standard conditions, have the preceding station on the link send a through tone by setting the order-wire transmitter ORDER WIRE TEST SWITCH to the THRU TONE position. Turn the order-wire transmitter front panel meter selector switch to the AUDIO position; note the meter reading. Adjust for the desired local handset audio level by means of the AUDIO LEVEL control in the order-wire receiver, then return the AUDIO meter to the original reading by adjusting the AUDIO LEVEL THRU CHAN control in the order-wire transmitter.

d. On extremely long links, it may be desirable to adjust the through audio in the manner that video levels were adjusted. At the east terminal send a test tone. At each succeeding repeater in the east facing order-wire receiver, adjust the AUDIO LEVEL control for the west facing order-wire transmitter reading of 100 when the ORDER WIRE panel meters selector switch is in the AUDIO position. Turn the ORDER WIRE TEST SWITCH to the THRU TONE position and note the AUDIO reading. Turn the ORDER WIRE TEST SWITCH to the LOCAL TONE position and adjust the AUDIO LEVEL LOCAL INPUT to give the same reading noted above. The AUDIO LEVEL LOCAL INPUT and AUDIO LEVEL THRU CHAN have now been balanced using a single *standard* oscillator to replace the local oscillator. Repeat from the west terminal, replacing east for west and vice versa in the above text.

99. Meter Readings

After the video adjustments have been made, the meter readings at each radio set should be noted and recorded on a form such as indicated in the chart below. Reference to this chart will be made in chapter 4.

Meter reading chart

Station...... Equipment serial No.......

Meter	Switch position	Normal range	Reading after installation or correction maintenance	Week	Week	Week	Week	Week	Remarks
Radio transmitter:									
A..................	AFC 1ST MULT GRID.	50–130							
A..................	AFC MIXER......	35–65							

Meter reading chart

Station...... Equipment serial No......

Meter	Switch position	Normal range	Reading after installation or correction maintenance	Week	Week	Week	Week	Week	Remarks
A	KLYSTRON POWER OUT.	30–150							
A	PA CATH CUR.	100–125 (max)							
A	1ST LIM GRID	20 (min)							
A	AFC CORRECTION−.	0 ±5							
A	AFC CORRECTION+.	0 ±5							
A	REFL V	70–100							
A	BEAM V	97–103							
LINE VOLTS		115 (as close as possible).							
PEAK VTVM	NEG PEAK POS PEAK.	100%–10%[1] 100%							
B	AFC 2ND MULT GRID.	30–70							
B	WAVEMETER	30–100							
B	PA GRID CUR.	40–100							
B	PA POWER OUT	40–150							
B	ORDER WIRE CARR LEVEL.	50–80 (approx)							
B	PA PLATE V	50–90[2] (approx)							
B	+300V	95–105							
B	+250V	95–105							
B	+150V	95–105							
B	−150V	95–105							
Order-wire transmitter	CARR LIM GRID.	80–120							
	DISCR+	0 ±10							
	DISCR−								
	AUDIO[3]								
	+140V	90–110							
Radio receiver:									
A	AFC 2ND MULT GRID.	75–140							
A	AFC MIXER	30–130[4]							
A	AFC CORRECTION−.	0 ±5							
A	AFC CORRECTION+.	0 ±5							
A	IF. LEVEL	10–30							
A	WAVEMETER	30–100							
A	REFL V	60–140							
A	BEAM CUR.	85–110							
A	BEAM V	90–100							
B	AFC 1ST MULT GRID.	30–90							
B	AFC 3RD MULT GRID.	50–80							
B	AFC IF. LEVEL	20–100							
B	IF. MIXER	60–80							
B	IF. DISCR FREQ HIGH.	0 ±10							

Meter reading chart Station...... Equipment serial No......

Meter	Switch position	Normal range	Reading after installation or correction maintenance	Week	Week	Week	Week	Week	Remarks
B	IF. DISCR FREQ LOW.	0 ±10							
B	+150V	95–110							
B	+250V	95–110							
Order-wire receiver									
	OW CARR LEVEL.	50–100							
	DISCR+	0 ±20							
	DISCR−	0 ±20							
	AUDIO [3]								
	+140V	90–110							
	DIV CONT LEVEL [4].								
	DIV OPER [4]								

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[1] 10 percent for 23 channel; 100 percent for 45-channel operation.

[2] When PA CATH CUR. reading (left hand METER A) is 100.

[3] With ORDER WIRE TEST SWITCH in OPR position.

[4] Meter readings vary considerably over receiver operation. See figure 107 for typical reading. The readings for all channels should fall within the range indicated. Refer to chapter 4 for determination of proper reading.

100. Measurement of System Signal-to-Noise Ratio

a. General. The overall radio relay system signal-to-noise ratio should be measured both on a video and an audio (when applicable) basis. The results obtained should be compared with the signal-to-noise ratios calculated in paragraph 43. The procedures for making these measurements are given below.

b. Video Signal-to-Noise Ratio. To measure the video signal-to-noise ratio it is necessary to use a Ballantine Model 314 vacuum-tube voltmeter, or equivalent.

Note. If a Ballantine Model 314 vacuum-tube voltmeter is not available, use the procedure outlined in paragraph 247*g*. Proceed as follows:

(1) At the east terminal, connect the vacuum-tube voltmeter to the VIDEO OUTPUT MONITOR jack terminated by a 50-ohm resistor located in the rear of the radio receiver.

(2) Note the reading of the vacuum-tube voltmeter. It should be about 400 millivolts. This is the signal level.

(3) Use the order-wire channel and instruct the operator at the preceding station to place the MOD INPUT SEL SW to the GND position and to disconnect the cable from the ORDER WIRE CARRIER OUT jack at rear of the order-wire transmitter.

(4) Note the reading of the vacuum-tube voltmeter. This is the noise level. The signal-to-noise ratio for the west-to-east path is the reading obtained in the step described in (2) above divided by the reading obtained in this step. Reconnect the cable to the ORDER WIRE CARRIER OUT jack.

(5) Repeat the procedures given in (1) through (4) above for the east-to-west path. Use the west terminal receiver output.

c. Audio Signal-to-Noise Ratio. The signal-to-noise ratio at the output of the video equipment (usually an audio signal) should be measured. In the ppm radio relay system, a transmission measuring set is included at each terminal that measures the audio levels. As in the case of the video measurement, the audio level, first with signal and then without signal, should be recorded. The ratio of these two readings is the signal-to-noise ratio. Refer to the manual on Multiplexer Set AN/TCC–13 for procedures for making these measurements in the ppm radio relay system.

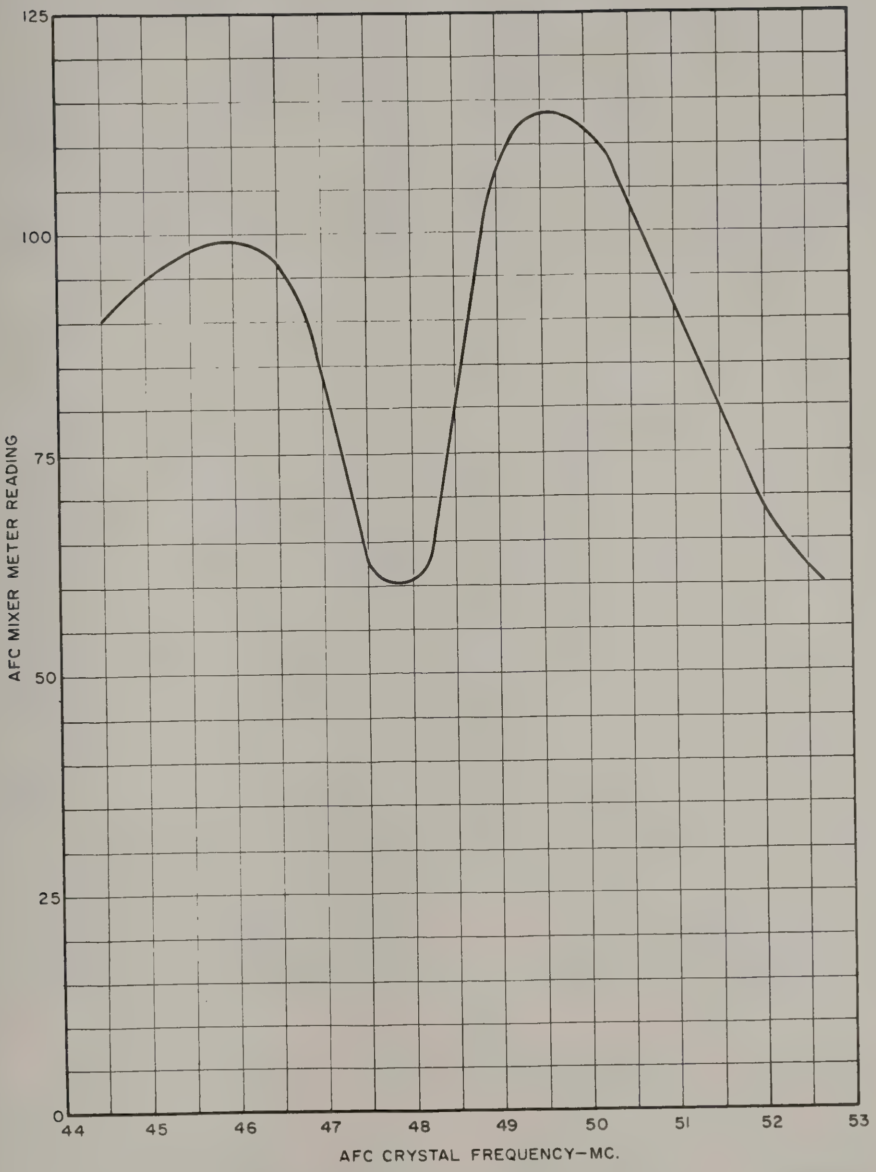

Figure 107. Typical AFC MIXER meter readings.

101. Adjustment of Fixed Autotransformer Power Transformer TF–146/G

In many installations, the primary power voltage varies substantially with the time of the day, the day of the week, and the season of the year. Consequently, although the output voltage of the autotransformer has been adjusted for 115 volts during the installation, it is possible that this voltage will vary considerably over long periods of time. During the first weeks and perhaps months of operation, the autotransformer output voltage (as seen on the LINE VOLTS meter) should be monitored frequently and recorded. After noting this output voltage over a long period of time, the INCREASE OUTPUT control on the autotransformer should be adjusted to provide a LINE VOLTS meter reading that results in a reading of 115 volts over the maximum period of time, and in the red sector of the meter at all times. When a 15 percent line voltage is anticipated and during periods when it is not possible to readjust the autotransformer, the INCREASE OUTPUT control may be set 5 percent higher as indicated on the LINE VOLTS meter. This will allow the line voltage to decrease the 10 percent allowable by equipment design plus the 5 percent gained by setting the INCREASE OUTPUT control 5 percent above normal.

CHAPTER 3

OPERATION

Section I. OPERATION UNDER USUAL CONDITIONS

102. General

This equipment is connected and adjusted for continuous 24-hour-a-day operation by installation and maintenance personnel, and no further adjustment by operating personnel is required. Paragraphs 103 to 106 describe the settings of controls (and indications) that are required for normal operation. Paragraph 107 describes the use of the order-wire channel. During maintenance tests, the operator may have to shut down an operating set and put the spare set into operation. The procedure for doing this is described in paragraph 108. The operator may also have to use the alternate primary power source (when available) (par. 109).

103. Setting of Control on Operating Equipment

The chart below lists the setting of operating controls on an operating radio set that the operator monitors. Meter switch positions are not listed in this table but are listed in chapter 2; they are not necessarily involved in normal operation. However, these switch positions may be required for maintenance tests or trouble-shooting. The proper meter readings for these switch positions are given in paragraph 99.

104. Indication of Proper Operation of Operating Sets

a. General. The operator should periodically monitor radio sets during operation to make sure that they are operating properly. Monitoring includes watching the pilot lamps and meter readings, and listening for the alarm buzzer (*b* through *d* below).

b. Pilot Lamps. The pilot lamps ((1) below) should be on. If any one of them goes off, particularly the TRANSMITTER OPERATING or RECEIVER ON lamp, maintenance personnel should be notified immediately. Refer to chapter 4 for trouble-shooting information.

(1) The following pilot lamps should be on:

(*a*) TRANSMITTER OPERATING lamp in the radio transmitter.

(*b*) POWER ON and HV PLATE ON

Control	Component	Setting
Meter (M1) and meter switch (S2) (figs. 85 and 108)	Order-wire transmitter	AUDIO.
METER A (M2) and meter switch (S4) (figs. 85 and 108)	Radio transmitter	AFC CORRECTION+.
PEAK VTVM meter (M4) and meter switch (S5) (figs. 86 and 108)	Radio transmitter	POS PEAK.
POWER circuit breaker (CB1) (fig. 109)	Radio transmitter	ON.
METER B (M1) and meter switch (S3) (figs. 86 and 108)	Radio transmitter	PA POWER OUT.
Meter (M1) and meter switch (S1) (fig. 110)	Order-wire receiver	OW CARR LEVEL.
METER A (M1) and meter switch (S2) (fig. 110)	Radio receiver	IF. LEVEL.
POWER circuit breaker (CB1) (fig. 110)	Radio receiver	ON.
METER B (M2) and meter switch (S3) (fig. 110)	Radio receiver	IF. MIXER.

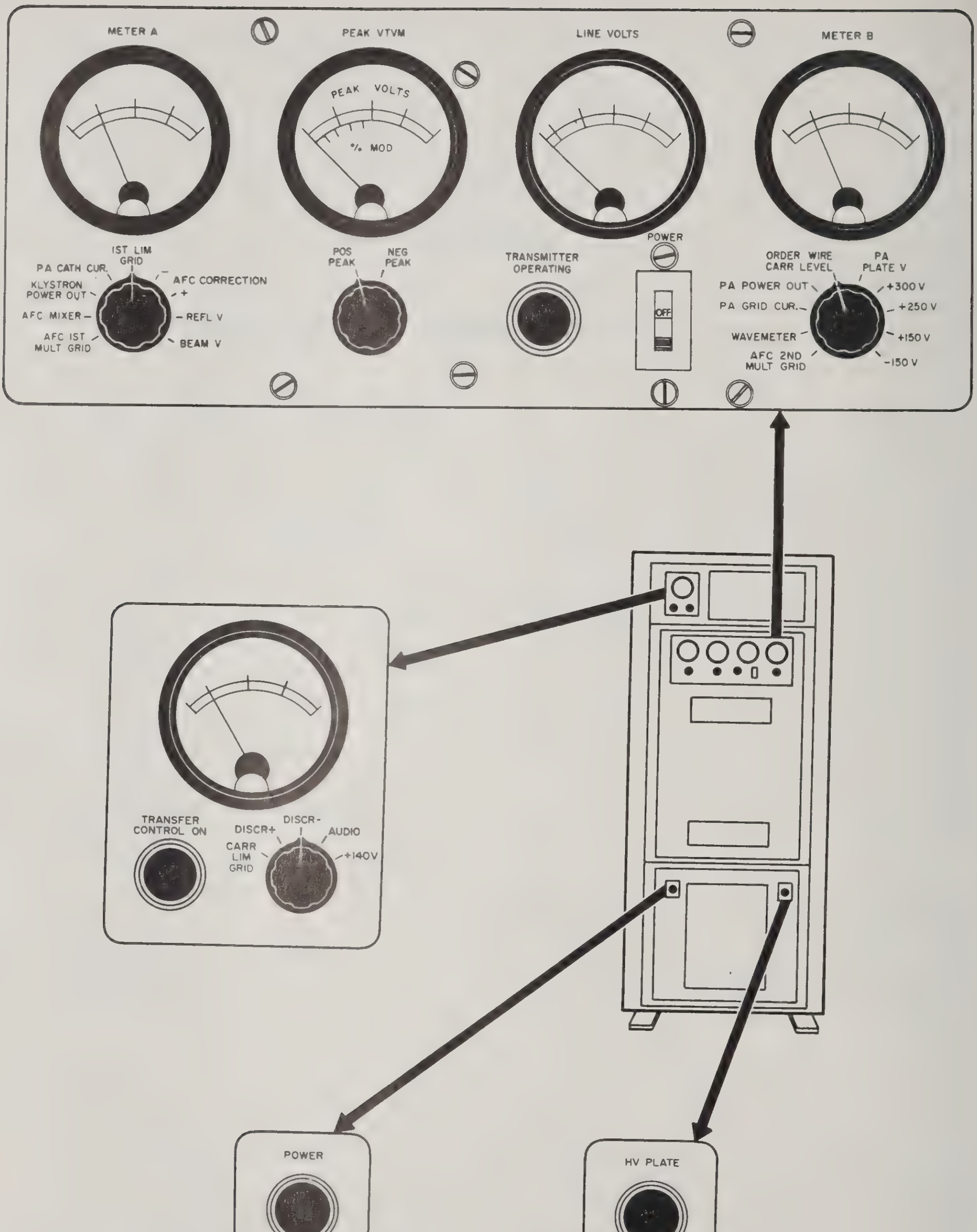
METER A
PEAK VTVM
PEAK VOLTS
% MOD
LINE VOLTS
METER B
1ST LIM GRID
PA CATH CUR.
AFC CORRECTION
+
KLYSTRON POWER OUT
AFC MIXER
REFL V
AFC 1ST MULT GRID
BEAM V
POS PEAK
NEG PEAK
TRANSMITTER OPERATING
POWER
OFF
ORDER WIRE CARR LEVEL
PA PLATE V
PA POWER OUT
+300 V
PA GRID CUR.
+250 V
WAVEMETER
+150 V
AFC 2ND MULT GRID
-150 V
TRANSFER CONTROL ON
DISCR-
DISCR+
AUDIO
CARR LIM GRID
+140V
POWER
ON
HV PLATE
ON
TM 689-377

Figure 108. Transmitter rack operating controls, front view.

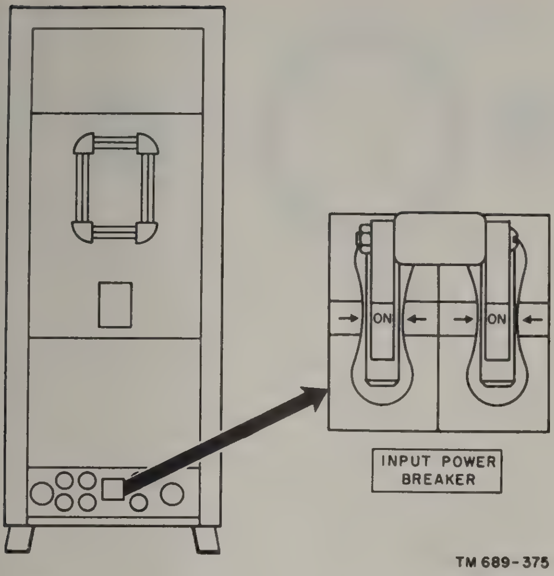

Figure 109. Transmitter rack operating controls, rear view.

lamps in the high-voltage power supply.

(*c*) RECEIVER ON lamp in the radio receiver.

(*d*) POWER ON and PLATE ON lamps in the receiver power supply.

(*e*) FILAMENT ON and LV PLATE ON lamps in the low-voltage power supply.

(2) The following pilot lamps should be off:

(*a*) TRANSFER CONTROL ON lamp in the order-wire transmitter.

(*b*) TRANSFER CONTROL ON lamp in the order-wire receiver.

c. Meter Readings. The chart below lists the correct meter readings. Maintenance should be informed if any meter reading falls outside the limits specified. Refer to chapter 4 for troubleshooting information.

Meter	Component	Limits
Meter M1 (fig. 108)	Order-wire transmitter	Follows audio when order-wire channel is used.
METER A (M2) (fig. 108)	Radio transmitter	0 ±5.
PEAK VTVM (M4) (fig. 108)	Radio transmitter	As specified by maintenance personnel.
LINE VOLTS (M4) (fig. 108)	Radio transmitter	Below 126.5 or above 103.5.
METER B (M1) (fig. 108)	Radio transmitter	40 percent of reading obtained during installation. Check with maintenance personnel.
Meter (M1) (fig. 110)	Order-wire receiver	40 minimum.
METER A (M1) (fig. 110)	Radio receiver	50 minimum.
METER B (M2) (fig. 110)	Radio receiver	48 minimum.

d. Buzzer. There is an alarm buzzer in the order-wire receiver. This buzzer monitors the received order-wire signal, and is silent when a proper microwave carrier signal is fed to the radio receiver and the receiving system is operating normally. If the microwave carrier signal is interrupted at any point along the transmission path between the two stations, including the preceding transmitter and the two antenna systems, or if any part of the receiving system fails, the buzzer will sound. Therefore maintenance should be informed whenever the buzzer sounds continuously.

Note. The alarm buzzer is also used for ringing. However ring buzzes cannot last longer than about 1 second each. If the buzzer sounds continuously, maintenance should be informed.

105. Setting of Controls and Indications on Spare Set

a. Setting of Controls. The setting of controls on the spare set should be the same as indicated in the table given in paragraph 103, except that the INPUT POWER BREAKER switches on the back of the high-voltage power supply should be in the OFF position.

b. Indications. All indicating lamps should be off and the meter readings should be zero, except the LINE VOLTS meter in the radio transmitter, which should read between 103.5 and 126.5 volts.

106. Setting of Controls and Indications on Radio Set Used for Diversity

a. Setting of Controls. The setting of controls on the radio set containing the preferred

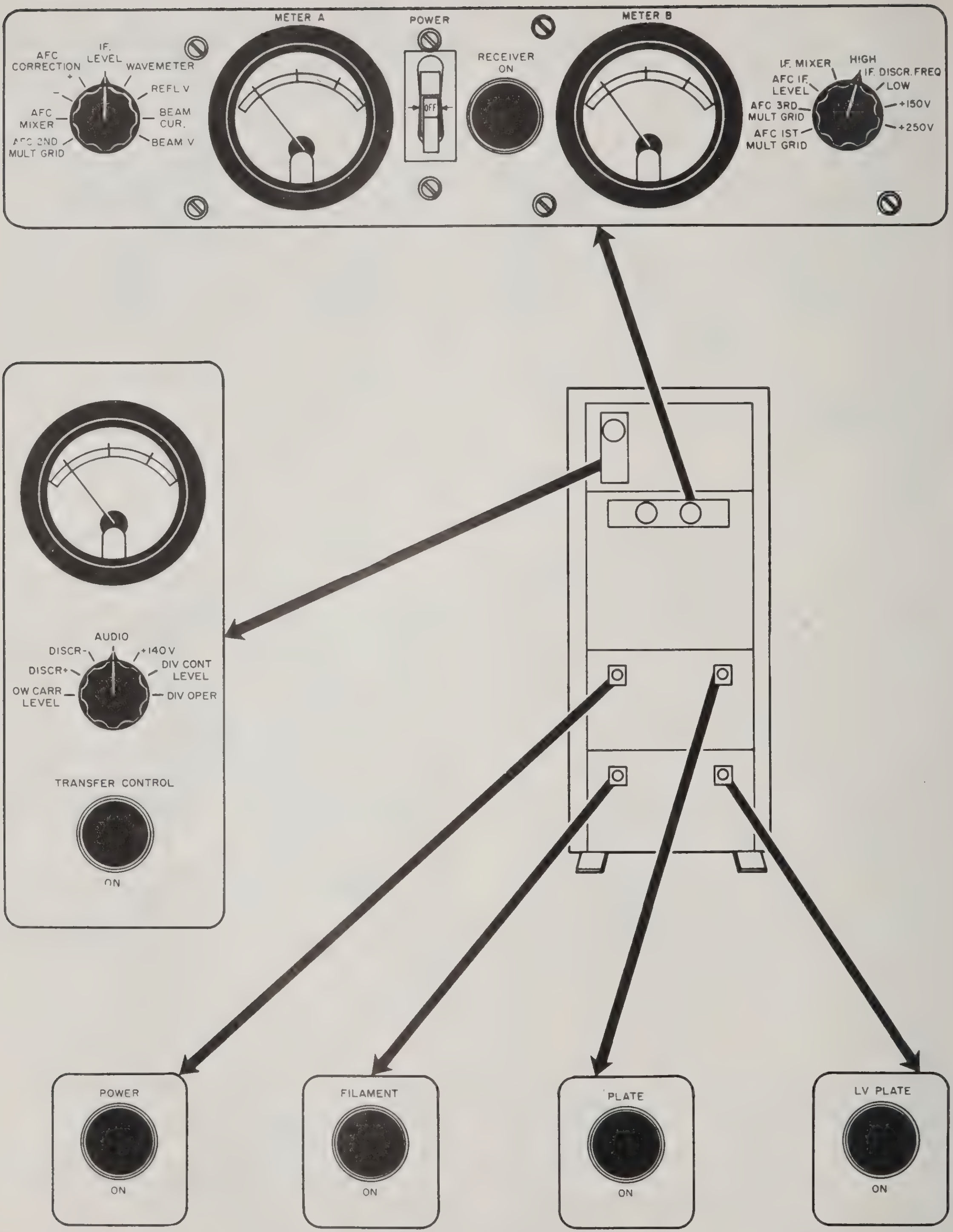
METER A
POWER
OFF
RECEIVER ON
METER B
AFC CORRECTION
I.F. LEVEL
WAVEMETER
+
−
REFL V
AFC MIXER
BEAM CUR.
AFC 2ND MULT GRID
BEAM V
I.F. MIXER
HIGH
I.F. DISCR. FREQ
AFC I.F. LEVEL
LOW
AFC 3RD MULT GRID
+150V
AFC 1ST MULT GRID
+250V
AUDIO
DISCR−
+140V
DISCR+
DIV CONT LEVEL
OW CARR LEVEL
DIV OPER
TRANSFER CONTROL
ON
POWER
ON
FILAMENT
ON
PLATE
ON
LV PLATE
ON

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Figure 110. Receiver rack operating controls.

receiver should be the same as indicated in paragraph 103. The setting of controls on the radio set containing the standby unit should also be the same except that the POWER switch in the radio transmitter should be in the OFF position.

b. Indications. The following indications should be obtained:

(1) *Preferred unit.* The indications given in paragraph 104 should be obtained on the preferred unit.

(2) *Standby unit.* On the standby unit the following should be obtained:

(*a*) *Indicating lamps.* Only the RECEIVER ON in radio receiver and the POWER ON and the PLATE ON lamps in the receiver power supply should be on.

(*b*) *Meter readings.* The following minimum meter readings should be obtained:

1. Meter (M1) on the order-wire receiver above 40.

2. Meter A (M1) on the radio receiver above 50.

3. Meter B (M2) on the radio receiver above 48.

107. Operation of Order-Wire Channel

It is possible to communicate with any station in the radio relay system over the order-wire channel. Stations should be assigned *party line* numbers in two digit groups, each digit to be no greater than five. Thus, a station with the assigned number 2–3 would respond to a series of two short rings, a pause, and then three short rings. The order-wire channel is operated in the following manner:

a. To Initiate a Call. To initiate a call, press the RING button on the order-wire receiver or ring the button on the side of a remote handset (fig. 111). The button should be pressed for a period of about a second, released, pressed again for the same length of time, released, and so on until the desired party line ring has been transmitted. The series of ring bursts should be sent several times until the called party responds.

Note. If the ring button is pressed for more than 1 second, the ringing will stop after about 1 second. To ring again, release the button and press it again.

b. To Talk. To talk, press the push-to-talk control on the handset and talk into the transmitting end of the handset.

Note. The handset can be used for both talking and listening when the push button is pressed. For reception only, release the pushbutton.

c. To Receive. To receive, place the receiver of the handset to the ear.

108. Connection of Spare Sets as Operating Set

Caution: Procedure given in this paragraph should be performed *only* when authorized.

a. General. Replace an operating set with the spare set as follows:

(1) Turn off the operating set to be replaced (*b* below).

(2) Reconnect the spare and the operating equipment so that the spare set can be used as an operating set (par. 64).

(3) Turn on spare set as described in *c* below.

b. Operating Set Stopping Procedure. Turn off the operating set as follows:

(1) Place the POWER switch in the radio transmitter in the OFF position. The TRANSMITTER OPERATING lamp in the radio transmitter, the POWER

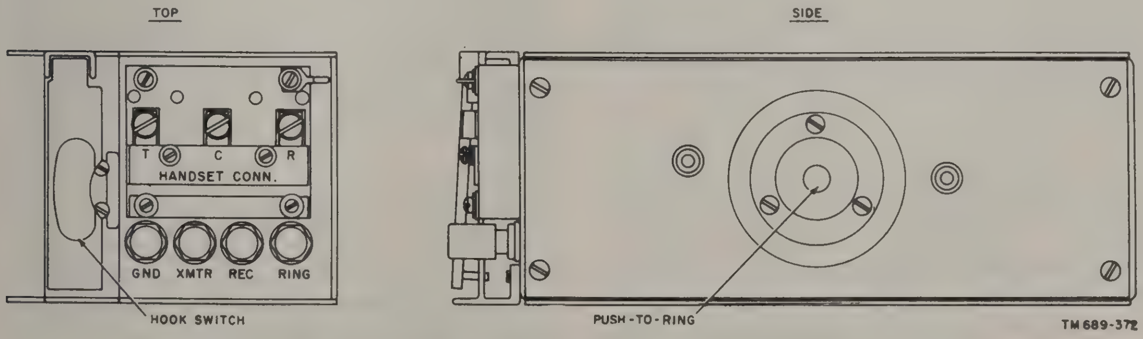


Figure 111. Handset-signaling operating controls.

ON and the HV PLATE ON lamps in the high-voltage power supply, and the FILAMENT ON and the LV PLATE ON lamps in the low-voltage power supply should go off.

(2) Place the POWER switch in the radio receiver in the OFF position. The RECEIVER ON lamp in the radio receiver and the POWER ON and the PLATE ON lamps in the receiver power supply should go off.

c. Spare Set Starting Procedure. Operate the spare set as follows:

(1) Place the POWER switch on the radio transmitter in the ON position. The POWER ON lamp in the high-voltage power supply and the FILAMENT ON lamp in the low-voltage power supply should come on. After about 60 seconds, the LV PLATE ON lamp in the low-voltage power supply, the HV PLATE ON lamp in the high-voltage power supply, and the TRANSMITTER OPERATING lamp in the radio transmitter should come on.

(2) Place the POWER switch on the radio receiver in the ON position. The POWER ON and the PLATE ON lamps in the receiver power supply, and the RECEIVER ON lamp in the radio receiver should come on.

(3) The minimum meter readings indicated in paragraph 104*c* should be obtained within a few minutes.

109. Use of Alternate Primary Power Source

Caution: Follow the procedure given in this paragraph only when authorized by maintenance.

Connect the alternate power source (when available) to the radio set by placing the switchbox INPUT SELECTOR SWITCH in the 1 position (fig. 112).

110. Stopping Procedure

a. Normal Stopping Procedure.

(1) Place the POWER switch (fig. 108) in the radio transmitter in the OFF position.

(2) Place the POWER switch (fig. 110) in the radio receiver in the OFF position.

b. Emergency Stopping Procedure. Place the INPUT POWER BREAKER (fig. 109) on the back of the high-voltage power supply in the OFF position.

Section II. OPERATION UNDER UNUSUAL CONDITIONS

111. General

The operation of Radio Set AN/TRC–29 may be difficult in areas having extreme cold, heat, humidity, and moisture. Although the equipment is designed to operate over a wide temperature and humidity range, extreme weather conditions may cause large measurement errors and interfere with normal operation. Paragraphs 112 through 114 provide procedures that will minimize the effects of bad weather.

112. Operation in Arctic Climates

Subzero temperatures and artic-type weather will present some difficulties. Instructions and precautions for operation under such adverse conditions follow:

a. Handle the equipment carefully.

b. Keep the equipment warm and dry.

c. Before turning on other voltages, turn on the filament voltages and let the tubes heat for 10 to 15 minutes.

113. Operation in Tropical Climates

When equipment is operated in tropical climates, it may be installed in tents or huts. When equipment is installed in swamp areas, the problem of moisture is apt to be serious, because heavy humidity causes moisture to condense on the equipment when the temperature of the equipment becomes lower than the surrounding air.

114. Operation in Desert Climates

a. The main concern with equipment operation in desert areas is the large amount of sand, dust, and dirt which may enter the moving parts of the radio equipment, such as motors and blowers. The ideal preventive measure is to

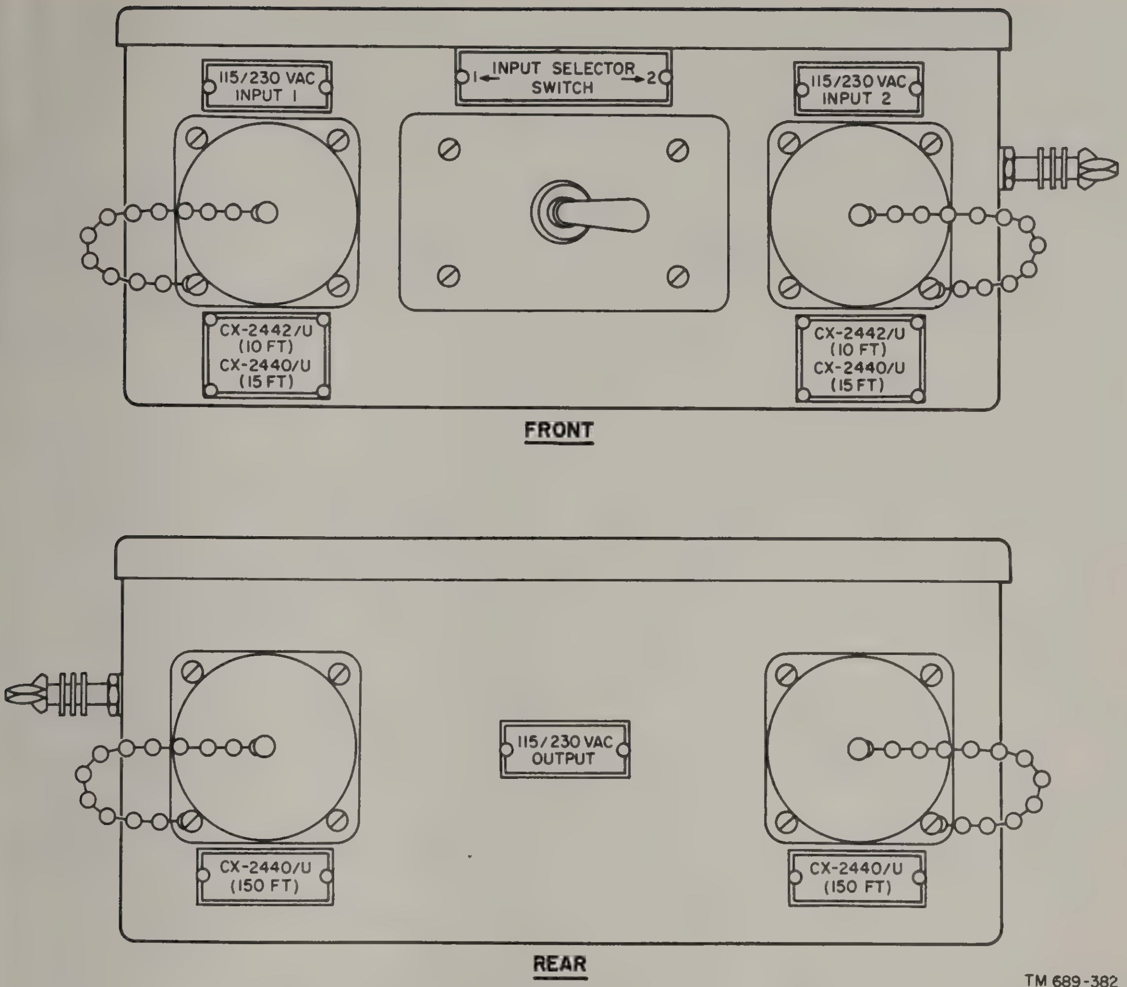

115/230 VAC INPUT 1
INPUT SELECTOR SWITCH
1 ← → 2
115/230 VAC INPUT 2
CX-2442/U (10 FT) CX-2440/U (15 FT)
CX-2442/U (10 FT) CX-2440/U (15 FT)
FRONT
115/230 VAC OUTPUT
CX-2440/U (150 FT)
CX-2440/U (150 FT)
REAR
TM 689-382

Figure 112. Switch Box SA–357/G, operating control.

house the equipment in a dustproof shelter. Because such a building is seldom available and would require air conditioning, the next best thing is to make the building in which the equipment is housed as dustproof as possible with available materials.

b. Keep the equipment as free from dust as possible. Make frequent preventive maintenance checks (ch. 4). Pay particular attention to the lubrication of the equipment.

115. Operation Under Conditions of Jamming

When an operator recognizes that his receiver is being jammed, he will promptly inform his immediate superior officer. To provide maximum intelligibility of jammed signals, he will follow the operational procedures below:

a. Vary the preselector INCR control very slightly for maximum IF. LEVEL meter reading. This step provides maximum signal on the desired frequency, and may provide some readthrough.

b. Request a change in frequency (channel) and call sign if the foregoing steps do not provide satisfactory communication.

c. If jamming action is so thorough and complete that communication is impossible, report this fact to the immediate superior. Continue to operate unless specifically instructed to do otherwise. The enemy may not realize his jamming success and may move to another frequency.

CHAPTER 4

ORGANIZATIONAL MAINTENANCE

Section I. TOOLS AND EQUIPMENT

116. Tools and Materials Required

The following tools and materials are not furnished as part of Radio Set AN/TRC–29 but are required for organizational maintenance:

Quantity	Description
1	Tool Equipment TE–41.
1	Tube Puller TL–201.
	Special tools (par. 117).

b. Materials.
  (1) Orange stick.
  (2) Cheesecloth, bleached, lint-free.
  (3) Cleaning Compound (Federal stock No. 7930–395–9542).
  (4) Sandpaper, flint, No. 000.

117. Special Tools Supplied With Radio Set AN/TRC–29

The following special tools (fig. 113) are supplied with each Radio Set AN/TRC–29.

a. Transmitter alinement tool (in transmitter rack).

b. Hexagonal socket wrench, No. 4 (in transmitter rack).

c. Hexagonal socket wrench, No. 8 (in transmitter rack).

d. Receiver alinement tool (in receiver rack).

e. Hexagonal socket wrench, No. 4 (in receiver rack).

f. Hexagonal socket wrench, No. 8 (in receiver rack).

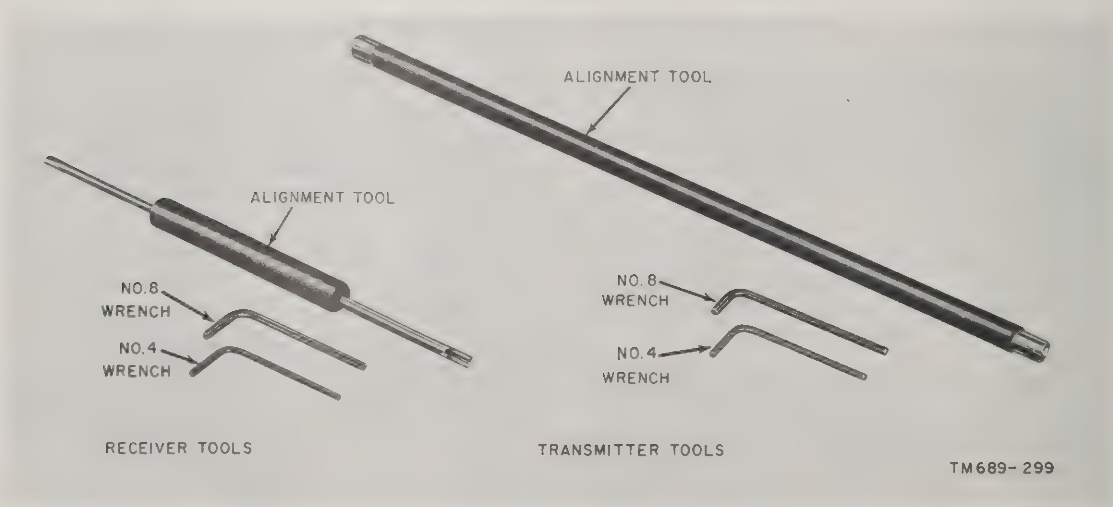

ALIGNMENT TOOL
ALIGNMENT TOOL
NO. 8 WRENCH
NO. 4 WRENCH
NO. 8 WRENCH
NO. 4 WRENCH
RECEIVER TOOLS
TRANSMITTER TOOLS
TM689-299

Figure 113. Special tools supplied with Radio Set AN/TRC–29.

118. Special Tool Not Supplied

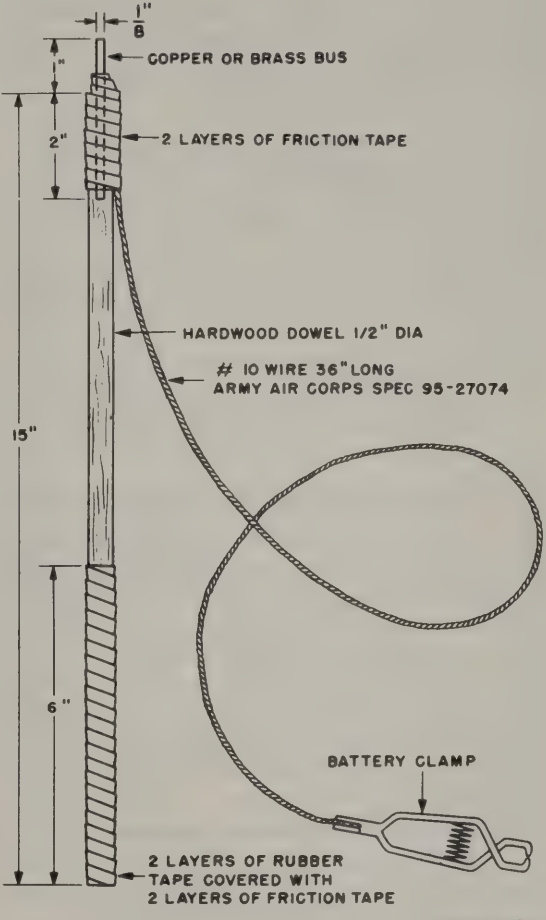
a. General. It is good practice to use a shorting stick to discharge capacitors before performing preventive maintenance or troubleshooting. When the power is turned off, the capacitors normally discharge to ground through bleeder resistors or voltage dividers. The discharge path may fail, however, causing the capacitors to remain charged. Contact with a charged capacitor may cause a severe shock; therefore, it is always advisable to discharge capacitors with a shorting stick.

b. How To Make a Shorting Stick. A shorting stick (fig. 114) can be made with materials usually on hand.

(1) Get a hardwood dowel approximately ½ inch in diameter and 15 inches long.
(2) Drill a ⅛-inch hole in one end of the dowel to a depth of 2 inches.
(3) Press fit a 3-inch piece of copper or bus wire into the hole as far as it will go.
(4) Solder one end of a 36-inch piece of No. 10 flexible standard wire to the bus wire as near to the dowel as possible.
(5) Attach a battery clamp to the other end of the wire.
(6) Apply several layers of friction tape over the soldered connection at the bus wire; leave about one-half inch of the bus wire bare.
(7) Extend the tape down over the dowel for about 2 inches.
(8) Form an insulated handle for the shorting stick by winding two layers of rubber tape and two layers of friction tape around the other end of the dowel for about 6 inches.

c. Use of Shorting Stick.

(1) Connect the battery clamp to a known chassis ground as close to the capacitor as is convenient.
(2) Hold the shorting stick by the insulated handle and touch the capacitor terminal with the exposed bus wire.



TM689-524

Figure 114. Shorting stick.

Section II. PREVENTIVE MAINTENANCE SERVICES

119. Definition of Preventive Maintenance

Preventive maintenance is work performed on equipment to keep it in good working condition so that breakdown and interruptions in service will be kept to a minimum. Preventive maintenance differs from troubleshooting and repair in that its object is to prevent trouble from occurring.

120. General Preventive Maintenance Techniques

a. Use No. 000 sandpaper to remove corrosion.

b. Use a clean, dry, lint-free cloth, such as cheesecloth, or a dry brush for cleaning all parts (including electrical contacts). If necessary, moisten the cloth or brush with cleaning compound; then wipe the parts dry with a cloth.

Caution: Prolonged breathing of cleaning compound fumes is dangerous. Make sure adequate ventilation is provided. Cleaning compound is inflammable; do not use near a flame.

c. For further information on general preventive maintenance techniques, refer to TB SIG 178.

121. Preventive Maintenance Procedures

a. Preventive maintenance in this equipment should be performed at weekly and monthly intervals.

b. Both weekly and monthly maintenance procedures are performed in the following two stages:

(1) Following standard preventive maintenance forms.
(2) Special preventive maintenance procedures.

122. Use of Preventive Maintenance Forms

a. DA Form 11–238 (fig. 115) and DA Form 11–239 (fig. 116) are to be used as preventive maintenance check lists as directed by the commander. Instructions for the use of each form appear on the reverse side of the form.

b. Items that are not lined out on figures 115 and 116 are applicable to Radio Set AN/TRC–29. References in the ITEM column are to paragraphs that contain additional detailed information.

c. To perform preventive maintenance, it is necessary to interrupt service for 15 minutes for weekly preventive maintenance and 1 hour for monthly preventive maintenance.

d. Because service must be interrupted for preventive maintenance, prepare a carefully planned schedule in which the *date* and *time* are indicated; make sure that the scheduled preventive maintenance is performed at the designated time. Maintenance should be scheduled during hours when traffic is normally light, whenever possible.

123. Special Preventive Maintenance

a. General. The basis for special preventive maintenance of this equipment is the observation and recording of all meter readings. These meter readings are taken and recorded in accordance with the meter reading chart made up during installation (par. 99).

b. Rate of Meter Reading Change. Many meter readings are expected to change as the tubes age. Generally, a relatively large change in meter reading is noted immediately after a new tube is inserted in the circuit associated with the meter reading. After a week or two, the meter reading for normal tube operation changes very gradually and constantly for a long period of time. Before the tube becomes completely defective, the rate of meter reading change increases. The tube should then be changed. Paragraph 124*b* indicates how the meter reading plus meter reading rate of change is used in preventive maintenance of this equipment.

c. Use of Spare Equipment. At most installations, there is a spare Radio Set AN/TRC–29 that has the following preventive maintenance uses:

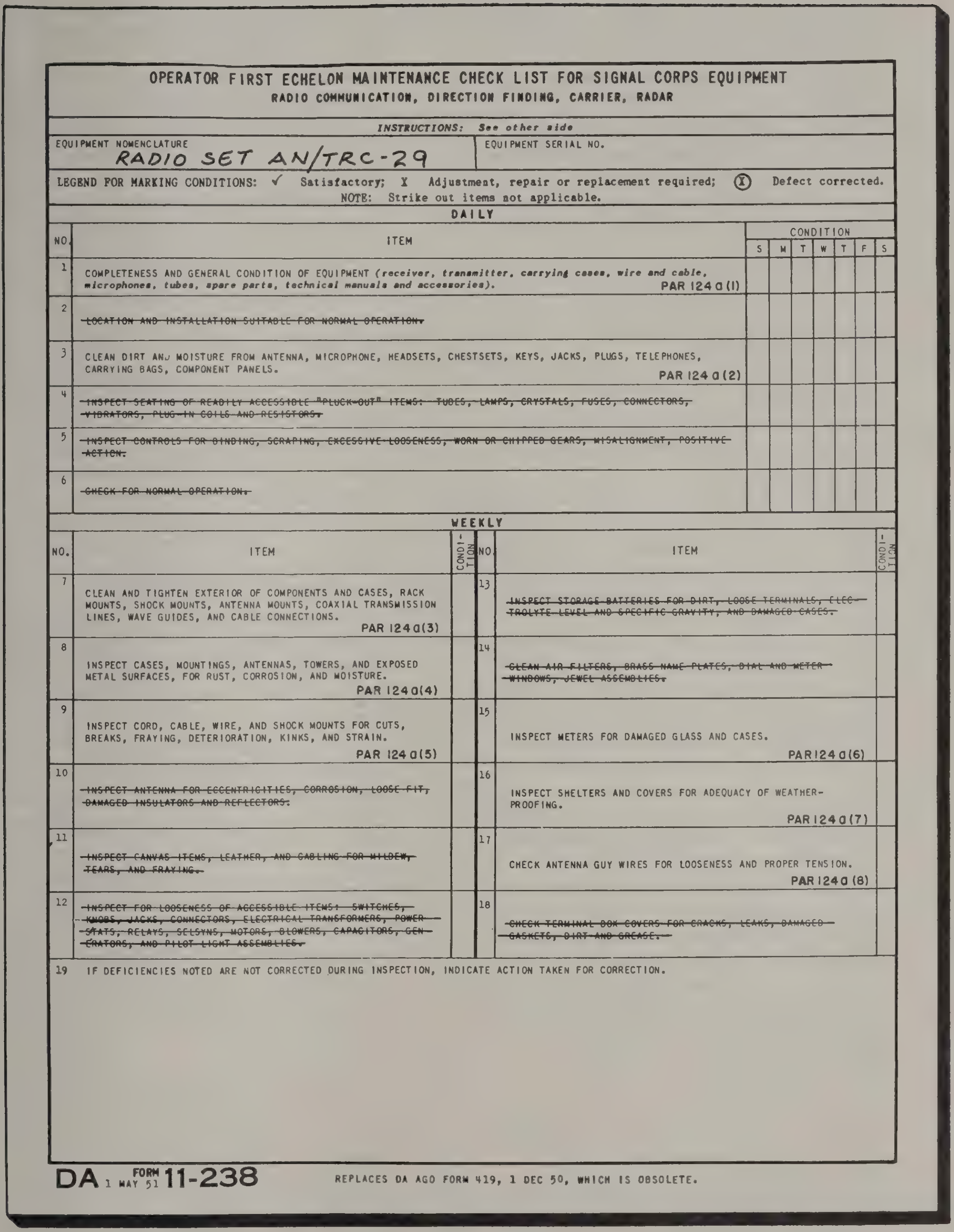
(1) The spare set is used in place of the principal set which, on the basis of meter readings, is likely to fail. The questionable set now becomes the spare, and corrective maintenance can be performed on it without interrupting service.
(2) The spare set is placed in operation in rotation with the other set; this keeps all sets in good working condition.

124. Performing Weekly Maintenance

Caution: Tighten screws, bolts, and nuts carefully. Fittings tightened beyond the pressure for which they are designed will be damaged or broken.

a. Using DA Form 11–238 (fig. 115), perform the following weekly preventive maintenance:

(1) Check for completeness and general condition of the set. Inspect the exterior and front panels of each component for dust or foreign matter; remove with dry, clean cloth moistened with cleaning compound.
(2) Remove dirt and moisture from antenna, jacks, and handsets.
(3) Check all ground connections. Keep



OPERATOR FIRST ECHELON MAINTENANCE CHECK LIST FOR SIGNAL CORPS EQUIPMENT
RADIO COMMUNICATION, DIRECTION FINDING, CARRIER, RADAR

INSTRUCTIONS: See other side

EQUIPMENT NOMENCLATURE RADIO SET AN/TRC-29

EQUIPMENT SERIAL NO.

LEGEND FOR MARKING CONDITIONS: ✓ Satisfactory; X Adjustment, repair or replacement required; Ⓧ Defect corrected.
NOTE: Strike out items not applicable.

DAILY

NO.	ITEM	CONDITION						
		S	M	T	W	T	F	S
1	COMPLETENESS AND GENERAL CONDITION OF EQUIPMENT (*receiver, transmitter, carrying cases, wire and cable, microphones, tubes, spare parts, technical manuals and accessories*). PAR 124 a (1)							
2	~~LOCATION AND INSTALLATION SUITABLE FOR NORMAL OPERATION.~~							
3	CLEAN DIRT AND MOISTURE FROM ANTENNA, MICROPHONE, HEADSETS, CHESTSETS, KEYS, JACKS, PLUGS, TELEPHONES, CARRYING BAGS, COMPONENT PANELS. PAR 124 a (2)							
4	~~INSPECT SEATING OF READILY ACCESSIBLE "PLUCK-OUT" ITEMS: TUBES, LAMPS, CRYSTALS, FUSES, CONNECTORS, VIBRATORS, PLUG-IN COILS AND RESISTORS.~~							
5	~~INSPECT CONTROLS FOR BINDING, SCRAPING, EXCESSIVE LOOSENESS, WORN OR CHIPPED GEARS, MISALIGNMENT, POSITIVE ACTION.~~							
6	~~CHECK FOR NORMAL OPERATION.~~							

WEEKLY

NO.	ITEM	CONDITION	NO.	ITEM	CONDITION
7	CLEAN AND TIGHTEN EXTERIOR OF COMPONENTS AND CASES, RACK MOUNTS, SHOCK MOUNTS, ANTENNA MOUNTS, COAXIAL TRANSMISSION LINES, WAVE GUIDES, AND CABLE CONNECTIONS. PAR 124 a (3)		13	~~INSPECT STORAGE BATTERIES FOR DIRT, LOOSE TERMINALS, ELECTROLYTE LEVEL AND SPECIFIC GRAVITY, AND DAMAGED CASES.~~	
8	INSPECT CASES, MOUNTINGS, ANTENNAS, TOWERS, AND EXPOSED METAL SURFACES, FOR RUST, CORROSION, AND MOISTURE. PAR 124 a (4)		14	~~CLEAN AIR FILTERS, BRASS NAME PLATES, DIAL AND METER WINDOWS, JEWEL ASSEMBLIES.~~	
9	INSPECT CORD, CABLE, WIRE, AND SHOCK MOUNTS FOR CUTS, BREAKS, FRAYING, DETERIORATION, KINKS, AND STRAIN. PAR 124 a (5)		15	INSPECT METERS FOR DAMAGED GLASS AND CASES. PAR 124 a (6)	
10	~~INSPECT ANTENNA FOR ECCENTRICITIES, CORROSION, LOOSE FIT, DAMAGED INSULATORS AND REFLECTORS.~~		16	INSPECT SHELTERS AND COVERS FOR ADEQUACY OF WEATHERPROOFING. PAR 124 a (7)	
11	~~INSPECT CANVAS ITEMS, LEATHER, AND CABLING FOR MILDEW, TEARS, AND FRAYING.~~		17	CHECK ANTENNA GUY WIRES FOR LOOSENESS AND PROPER TENSION. PAR 124 a (8)	
12	~~INSPECT FOR LOOSENESS OF ACCESSIBLE ITEMS: SWITCHES, KNOBS, JACKS, CONNECTORS, ELECTRICAL TRANSFORMERS, POWERSTATS, RELAYS, SELSYNS, MOTORS, BLOWERS, CAPACITORS, GENERATORS, AND PILOT LIGHT ASSEMBLIES.~~		18	~~CHECK TERMINAL BOX COVERS FOR CRACKS, LEAKS, DAMAGED GASKETS, DIRT AND GREASE.~~	

19 IF DEFICIENCIES NOTED ARE NOT CORRECTED DURING INSPECTION, INDICATE ACTION TAKEN FOR CORRECTION.

DA FORM 1 MAY 51 11-238 REPLACES DA AGO FORM 419, 1 DEC 50, WHICH IS OBSOLETE.

TM689-480

Figure 115. DA Form 11-238.

connections clean and tight. Check all mountings, screws, nuts, bolts, and connections for looseness. Check to see that tube clamps are in good condition.

(4) Inspect cases, mountings, antenna assemblies, towers, and exposed metal surfaces for rust and corrosion. Remove with a dry, clean cloth moistened with cleaning compound, and wipe with a dry cloth.

(5) Inspect cables for poor insulation, especially at connecting points. Look for improper connections which strain wires or connectors.

(6) Inspect meters and indicator-lamp windows for damaged glass. Clean meter and indicator-lamp windows.

(7) Inspect station shelter for adequate weatherproofing.

(8) Inspect the antenna guy wires for looseness and proper tension. Check bolts that hold the antenna in place.

b. Special Maintenance Procedure. Perform weekly special preventive maintenance as follows:

(1) Note and record the LINE VOLTS meter reading on the radio transmitter. If it is not within 4 volts of 115 volts, adjust the INCREASE OUTPUT control on the autotransformer for a reading as close to 115 volts as possible.

(2) The wavemeter in both the radio transmitter and the radio receiver should be adjusted for a peak meter reading; the meter reading and the setting obtained after adjustment should be recorded. The VARIABLE AUTOTRANSFORMER knob on the high-voltage power supply should be adjusted for a PA CATH CUR. (radio transmitter) meter reading of 100.

(3) Note and record all the meter readings on the operating equipment, including the IF. LEVEL meter reading with the IF. LEVEL control maximum clockwise. This latter reading may be off scale. After noting this reading, readjust the IF. LEVEL control as described in paragraph 91*e* and *f*.

(4) On the spare set, place the INPUT POWER BREAKER switches (high-voltage power supply) in the ON positions and allow the equipment to warm up for about 15 minutes. Note and record all meter readings on the spare equipment. The IF. LEVEL meter reading, which is with no signal input, should be recorded on the meter reading chart.

(5) Determine the rate of change of each meter reading, which is the previous meter reading minus the present meter reading. Subtract the rate of change value from the meter reading. This is the anticipated meter reading for next week. For example, assume that the previous meter reading is 83 and the present reading is 80. The rate of change is 83 minus 80, or 3. The anticipated meter reading is 80 minus 3, or 77.

(6) If the anticipated meter reading is below the minimum specified in the chart below, corrective maintenance should be performed on the equipment. Refer to paragraph 132 for corrective maintenance. The spare set (when its meter readings are all within the specified limits) should be used in place of any set that requires corrective maintenance. See paragraph 108 for procedure on substituting a spare set for an operating set.

Meter reading chart

Meter	Switch position	Special conditions	Limits
Radio transmitter:			
A	AFC 1ST MULT GRID	None	40 minimum.
A	AFC MIXER	None	28 minimum.
A	KLYSTRON POWER OUT	Note reading obtained at installation	60% of installation reading.

Meter reading chart

Meter	Switch position	Special conditions	Limits
A	PA CATH CUR.	See (2) above	Meter reading of 100 should be obtained.
A	1ST LIM. GRID	None	20 minimum.
A	AFC CORRECTION+ and AFC CORRECTION−.	Note + and − readings. Use average value.	±5.
A	REFL V	Note reading obtained at installation	80% (min) to 120% (max) of installation reading.
A	BEAM V	None	97 (min) to 103 (max).
B	AFC 2ND MULT GRID	None	24 minimum.
B	WAVEMETER (meter reading).	See (2) above	30 minimum.
	WAVEMETER (setting)	See (2) above. Note setting obtained during installation.	1.0 mc different from installation reading. Use calibration chart to determine frequency difference.
B	PA GRID CUR.	None	28 minimum.
B	PA POWER OUT	Note reading obtained at installation	40% of installation reading.
B	ORDER WIRE CARR LEVEL.	Note reading obtained at installation	80% of installation reading.
B	PA PLATE V	PA CATH CUR. at 100	50 (min) to 90 (max).
B	+300V	None	95 (min) to 105 (max).
B	+250V	None	95 (min) to 105 (max).
B	+150V	None	95 (min) to 105 (max).
B	−150V	None	95 (min) to 105 (max).
PEAK PEAK VTVM	NEG PEAK	VTVM SEL SW in GND position. Adjust NEG PEAK control for a zero reading.	0 meter reading should be obtained.
PEAK VTVM	POS PEAK	VTVM SEL SW in GND position. Adjust POS PEAK control for a zero reading.	0 meter reading should be obtained.
PEAK VTVM	NEG PEAK or POS PEAK	VTVM SEL SW in MON OUT position. Reading obtained at terminal originating modulation signal should be determined.	±10% of reading obtained in column 3.
PEAK VTVM	NEG PEAK or POS PEAK	VTVM SEL SW in MOD IN position. Reading obtained at terminal originating modulation should be determined.	±10% of reading obtained in column 3.
PEAK VTVM	NEG PEAK or POS PEAK	VTVM SEL SW in MOD OUT position. Note ratio $\frac{\text{MOD OUT}}{\text{MOD IN}}$ at installation.	Ratio $\frac{\text{MOD OUT}}{\text{MOD IN}}$ should be within 10% of ratio obtained in column 3.
PEAK VTVM	NEG PEAK or POS PEAK	VTVM SEL SW in MON OUT position. Note ratio $\frac{\text{MON OUT}}{\text{MOD OUT}}$ at installation.	Ratio $\frac{\text{MON OUT}}{\text{MOD OUT}}$ should be within 10% of ratio obtained in column 3.
Order-wire transmitter.	CARR LIM GRID	None	64 minimum.
	DISCR+	Note DISCR-reading. Use average value.	±10.
	AUDIO	ORDER WIRE TEST SWITCH in THRU TONE position.	56 (min) to 130 (max).
	AUDIO	ORDER WIRE TEST SWITCH in LOCAL TONE position.	56 (min) to 130 (max).
	+140V	None	90 (min) to 110 (max).

Meter reading chart

Meter	Switch position	Special conditions	Limits
Radio receiver:			
A	AFC 2ND MULT GRID	None	60 minimum.
A	AFC MIXER	None	30 minimum.
A	AFC CORRECTION+ and AFC CORRECTION−.	Note + and − reading. Use average of both readings.	±5.
A	IF. LEVEL	No input signal (spare set)	8 minimum.
A	IF. LEVEL	IF. LEVEL control fully clockwise (no age).	125 (**actual, not anticipated**; that is, do not deduct rate of change from this reading).
A	WAVEMETER (meter reading).	See (2) above	30 minimum.
A	WAVEMETER (setting)	See (2) above. Note setting obtained at installation.	1.0 mc different from installation reading (use calibration chart to determine frequency difference).
A	REFL V	Note reading obtained at installation	±5 divisions from installation reading.
A	BEAM CUR.	Note reading obtained at installation	±5 divisions from installation reading.
A	BEAM V	Note reading obtained at installation	±5 divisions from installation reading.
B	AFC 1ST MULT GRID	None	24 minimum.
B	AFC 3RD MULT GRID	None	40 minimum.
B	AFC IF. LEVEL	None	20 minimum.
B	IF. MIXER	None	48 minimum.
B	IF. DISCR FREQ HIGH	None	±10.
B	IF. DISCR FREQ LOW	None	±10.
B	+150V	None	95 (min) to 110 (max).
B	+250V	None	95 (min) to 110 (max).
Order-wire receiver	OW CARR LEVEL	None	40 minimum.
	DISCR+	Note DISCR− reading. Use average value.	±20.
	AUDIO	Follows audio with voice modulation.	
	+140V	None	90 (min) to 110 (max).
	DIV CONT LEVEL	Diversity operation	30 minimum.
	DIV OPER	Diversity operation when operating	90 (min) to 110 (max).
	DIV OPER	Diversity operation, when standby	±3.

(7) If all the operating and spare equipments provide proper meter readings, the spare set should be substituted for an operating equipment on a rotation basis. The procedure for connecting the spare set in place of an operating set is given in paragraph 108.

(8) After the spare set is connected as an operating equipment, adjust the PLATE TUNING control for maximum PA PLATE TUNING meter reading. Check the IF. LEVEL meter reading with the IF. LEVEL control fully clockwise and record this reading. It should be greater than 125; then readjust the IF. LEVEL control as described in paragraph 91*e* and *f*.

(9) Readjust the INCREASE OUTPUT control on all autotransformers (par. 101) for the reading obtained in (1) above.

(10) On the radio set now being used as a spare, place the INPUT POWER BREAKER switch in the *off* position.

(11) Before leaving the station, ring out and call both the east and west terminals; check both handsets in the process.

c. Maintenance of Radio Frequency Transmission Line Assembly CG–1013/U (figs. 73 and 74).

(1) Check to see that the transmission line is taut and that the power cables and rf cables are taped securely to prevent wind whipping.

(2) Check all cable assemblies for cracked, cut, or frayed insulation.

(3) Check all electrical connections for tightness.

Caution: Be sure that the de-icing transformer assembly ac line switch is in the OFF position. The de-icing connections may be inspected without shutting down the radio station.

(4) During preventive maintenance periods on the radio equipment, check the rf connectors for corrosion and looseness; check the launching units for dents, cracks, corrosion and water leakage, dirt, and insects; check the connection between the transmission line and the launching unit.

Caution: When performing a maintenance check on the upper launching unit, be sure that the nylon rope assembly is attached securely to the housing at all times to prevent the cone and shield of the upper launching unit from sliding down the transmission line.

(5) Condensation of moisture inside the launching units may occur, but its pattern is distinguishable from that of water resulting from leakage. Drain holes permitting drainage from the cone are provided in the fire hose connector. Keep the fire hose connection clear of dirt so that water can drain out.

(6) The launching unit housing is a factory sealed unit and should not give trouble in the field. If trouble is suspected, substitute a launching unit known to be good and note any difference in the received signal level for the transmission path. Defective launching unit housings may be serviced at depot levels having a kit of connector replacement parts available.

125. Performing Monthly Maintenance

Caution: Disconnect all power from the radio set before performing the following operations. Upon completion, reconnect power and check for satisfactory operation of the set.

a. Use of Standard Preventive Maintenance Forms. Using DA Form 11–239 (fig. 116) perform the following monthly preventive maintenance:

(1) Check tubes, tube sockets, and tube shields.

(2) Check capacitor cases for leakage, bulges, and discoloration. Replace leaky capacitors.

Caution: Some capacitors, especially those in power supply and voltage regulator circuits, may have a highly dangerous charge, even after power has been turned off. Use a shorting stick to short the terminals to the chassis.

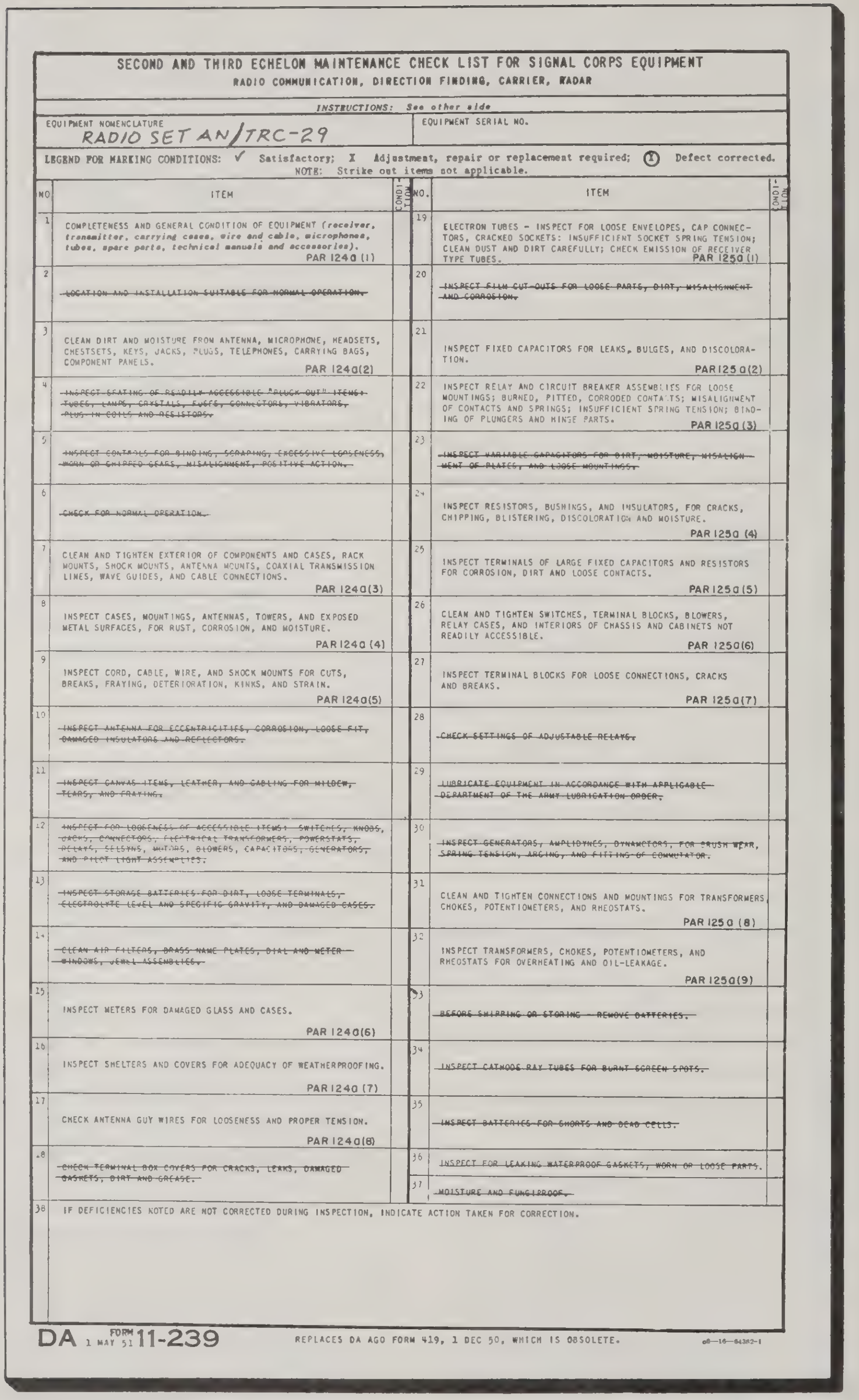
(3) Check circuit-breaker assemblies for loose mountings, insufficient spring tension, and binding of plungers or hinge parts. Replace defective assemblies.

(4) Inspect resistors for blistering, discoloring, and loose connections. Check tightness of terminals and mountings. Clean dirty connections or terminals with a cloth or brush dipped in cleaning compound. If a resistor is blistered or discolored, equipment may be operating under overload. The resistor should be replaced after cause of overload is determined.

Caution: Some resistors become discolored because of moistureproofing and fungiproofing treatment. Do not change these resistors.

(5) Inspect capacitors for corrosion of cases and terminals, and also for loose connections. Check to see that mounting brackets and clamps are firmly secured to chassis, and that all capacitors are held firmly in place. Examine all leads for poor insulation, cracks, and frayed strands. If a wire is exposed, use friction tape to cover it. Use dry cloth to clean the case and any connections that are dirty or corroded.

Caution: Some capacitors, especial-



SECOND AND THIRD ECHELON MAINTENANCE CHECK LIST FOR SIGNAL CORPS EQUIPMENT

RADIO COMMUNICATION, DIRECTION FINDING, CARRIER, RADAR

INSTRUCTIONS: See other side

EQUIPMENT NOMENCLATURE RADIO SET AN/TRC-29	EQUIPMENT SERIAL NO.

LEGEND FOR MARKING CONDITIONS: ✓ Satisfactory; X Adjustment, repair or replacement required; Ⓧ Defect corrected.
NOTE: Strike out items not applicable.

NO	ITEM	CONDITION	NO.	ITEM	CONDITION
1	COMPLETENESS AND GENERAL CONDITION OF EQUIPMENT *(receiver, transmitter, carrying cases, wire and cable, microphones, tubes, spare parts, technical manuals and accessories).* PAR 124a (1)		19	ELECTRON TUBES - INSPECT FOR LOOSE ENVELOPES, CAP CONNECTORS, CRACKED SOCKETS: INSUFFICIENT SOCKET SPRING TENSION; CLEAN DUST AND DIRT CAREFULLY; CHECK EMISSION OF RECEIVER TYPE TUBES. PAR 125a (1)	
2	~~LOCATION AND INSTALLATION SUITABLE FOR NORMAL OPERATION.~~		20	~~INSPECT FILM CUT-OUTS FOR LOOSE PARTS, DIRT, MISALIGNMENT AND CORROSION.~~	
3	CLEAN DIRT AND MOISTURE FROM ANTENNA, MICROPHONE, HEADSETS, CHESTSETS, KEYS, JACKS, PLUGS, TELEPHONES, CARRYING BAGS, COMPONENT PANELS. PAR 124a(2)		21	INSPECT FIXED CAPACITORS FOR LEAKS, BULGES, AND DISCOLORATION. PAR 125a(2)	
4	~~INSPECT SEATING OF READILY ACCESSIBLE "PLUCK-OUT" ITEMS: TUBES, LAMPS, CRYSTALS, FUSES, CONNECTORS, VIBRATORS, PLUG-IN COILS AND RESISTORS.~~		22	INSPECT RELAY AND CIRCUIT BREAKER ASSEMBLIES FOR LOOSE MOUNTINGS; BURNED, PITTED, CORRODED CONTACTS; MISALIGNMENT OF CONTACTS AND SPRINGS; INSUFFICIENT SPRING TENSION; BINDING OF PLUNGERS AND HINGE PARTS. PAR 125a (3)	
5	~~INSPECT CONTROLS FOR BINDING, SCRAPING, EXCESSIVE LOOSENESS, WORN OR CHIPPED GEARS, MISALIGNMENT, POSITIVE ACTION.~~		23	~~INSPECT VARIABLE CAPACITORS FOR DIRT, MOISTURE, MISALIGNMENT OF PLATES, AND LOOSE MOUNTINGS.~~	
6	~~CHECK FOR NORMAL OPERATION.~~		24	INSPECT RESISTORS, BUSHINGS, AND INSULATORS, FOR CRACKS, CHIPPING, BLISTERING, DISCOLORATION AND MOISTURE. PAR 125a (4)	
7	CLEAN AND TIGHTEN EXTERIOR OF COMPONENTS AND CASES, RACK MOUNTS, SHOCK MOUNTS, ANTENNA MOUNTS, COAXIAL TRANSMISSION LINES, WAVE GUIDES, AND CABLE CONNECTIONS. PAR 124a(3)		25	INSPECT TERMINALS OF LARGE FIXED CAPACITORS AND RESISTORS FOR CORROSION, DIRT AND LOOSE CONTACTS. PAR 125a (5)	
8	INSPECT CASES, MOUNTINGS, ANTENNAS, TOWERS, AND EXPOSED METAL SURFACES, FOR RUST, CORROSION, AND MOISTURE. PAR 124a (4)		26	CLEAN AND TIGHTEN SWITCHES, TERMINAL BLOCKS, BLOWERS, RELAY CASES, AND INTERIORS OF CHASSIS AND CABINETS NOT READILY ACCESSIBLE. PAR 125a(6)	
9	INSPECT CORD, CABLE, WIRE, AND SHOCK MOUNTS FOR CUTS, BREAKS, FRAYING, DETERIORATION, KINKS, AND STRAIN. PAR 124a(5)		27	INSPECT TERMINAL BLOCKS FOR LOOSE CONNECTIONS, CRACKS AND BREAKS. PAR 125a(7)	
10	~~INSPECT ANTENNA FOR ECCENTRICITIES, CORROSION, LOOSE FIT, DAMAGED INSULATORS AND REFLECTORS.~~		28	~~CHECK SETTINGS OF ADJUSTABLE RELAYS.~~	
11	~~INSPECT CANVAS ITEMS, LEATHER, AND CABLING FOR MILDEW, TEARS, AND FRAYING.~~		29	~~LUBRICATE EQUIPMENT IN ACCORDANCE WITH APPLICABLE DEPARTMENT OF THE ARMY LUBRICATION ORDER.~~	
12	~~INSPECT FOR LOOSENESS OF ACCESSIBLE ITEMS: SWITCHES, KNOBS, JACKS, CONNECTORS, ELECTRICAL TRANSFORMERS, POWERSTATS, RELAYS, SELSYNS, MOTORS, BLOWERS, CAPACITORS, GENERATORS, AND PILOT LIGHT ASSEMBLIES.~~		30	~~INSPECT GENERATORS, AMPLIDYNES, DYNAMOTORS, FOR BRUSH WEAR, SPRING TENSION, ARCING, AND FITTING OF COMMUTATOR.~~	
13	~~INSPECT STORAGE BATTERIES FOR DIRT, LOOSE TERMINALS, ELECTROLYTE LEVEL AND SPECIFIC GRAVITY, AND DAMAGED CASES.~~		31	CLEAN AND TIGHTEN CONNECTIONS AND MOUNTINGS FOR TRANSFORMERS, CHOKES, POTENTIOMETERS, AND RHEOSTATS. PAR 125a (8)	
14	~~CLEAN AIR FILTERS, BRASS NAME PLATES, DIAL AND METER WINDOWS, JEWEL ASSEMBLIES.~~		32	INSPECT TRANSFORMERS, CHOKES, POTENTIOMETERS, AND RHEOSTATS FOR OVERHEATING AND OIL-LEAKAGE. PAR 125a(9)	
15	INSPECT METERS FOR DAMAGED GLASS AND CASES. PAR 124a(6)		33	~~BEFORE SHIPPING OR STORING - REMOVE BATTERIES.~~	
16	INSPECT SHELTERS AND COVERS FOR ADEQUACY OF WEATHERPROOFING. PAR 124a (7)		34	~~INSPECT CATHODE RAY TUBES FOR BURNT SCREEN SPOTS.~~	
17	CHECK ANTENNA GUY WIRES FOR LOOSENESS AND PROPER TENSION. PAR 124a(8)		35	~~INSPECT BATTERIES FOR SHORTS AND DEAD CELLS.~~	
18	~~CHECK TERMINAL BOX COVERS FOR CRACKS, LEAKS, DAMAGED GASKETS, DIRT AND GREASE.~~		36	~~INSPECT FOR LEAKING WATERPROOF GASKETS, WORN OR LOOSE PARTS.~~	
			37	~~MOISTURE AND FUNGIPROOF.~~	
38	IF DEFICIENCIES NOTED ARE NOT CORRECTED DURING INSPECTION, INDICATE ACTION TAKEN FOR CORRECTION.				

DA FORM 1 MAY 51 11-239 REPLACES DA AGO FORM 419, 1 DEC 50, WHICH IS OBSOLETE. o8—16—84382-1

TM689-481

Figure 116. DA Form 11–239.

ly large electrolytics, may have a highly dangerous charge after power has been turned off. Use a shorting stick to short terminals to the case.

(6) Where possible, check switches for accumulation of dirt, corrosion, or grease. Check for loose contacts and unsatisfactory mechanical action. Frequently, the elements of a switch may be examined visually. To test the action of switches, rotate a control knob or press a button, and note the freedom of movement and amount of spring tension. Always note the original position of a control being tested, and restore it to the original position after testing. Inspect the ganged switches to see if contacts are clean. Do not pry the contacts of the switches apart. A rotary member should make contact with a stationary member and, as the former slides into the latter, a spreading of contacts should be noticeable. Clean the exterior surfaces of switches with a stiff brush moistened with cleaning compound; then polish with dry cloth. Clean, burnish, and adjust wafter-type switches.

(7) Check terminal boards for loose connections, breakage, dust, dirt, and grease. Tighten loose mounting screws, lugs, and mounting bolts. Clean terminal boards with a dry brush. When necessary, use a cloth moistened with cleaning compound. If solvent is used, the terminal board must be cleaned thoroughly. Be careful when tightening screws. Do not exert much pressure because the terminal board may crack.

(8) Check locknuts on all screwdriver adjustment controls to make sure they are tight. If any are found to be loose, tighten and check the control for correct adjustment (by noting associated meter reading on meter reading chart). Use a hexagonal wrench to tighten the locknut. When tightening the locknut, check to make sure that the setting of the control has not slipped during the locking procedure.

(9) Inspect transformers and filters for general cleanliness, tightness of connections, and evidences of overheating or leaking of potting compound. Potting compound found on the outside of transformer ordinarily indicates overheating and probably a damaged part. Check the associated circuits carefully for cause of overheating, such as shorts or excessive current. Tighten loose connections and mounting screws. Clean transformers and filters with a dry cloth. Examine glass seals for evidences of cracks or breakage. Transformers are hermetically sealed; if glass seals are broken, operation of transformers may be seriously impaired.

b. Special Maintenance Procedure. Perform special monthly maintenance as follows:

(1) Note and record the LINE VOLTS meter reading on the radio transmitter.

(2) Retune the transmitter and receiver of all sets in the following sequence:
  (*a*) Transmitter crystal multiplier chain (par. 76).
  (*b*) Transmitter klystron and power amplifier (par. 77).
  (*c*) Order-wire transmitter (par. 78).
  (*d*) Receiver crystal multiplier chain (par. 80).
  (*e*) Local oscillator (par. 83).
  (*f*) Order-wire receiver (par. 84).

(3) Readjust the operating sets on a single-hop basis as follows:
  (*a*) Orient the antennas (par. 90).
  (*b*) Perform the fine tuning of the preselector (par. 91).

(4) Perform all steps indicated for weekly preventive maintenance (par. 124*a*).

(5) Repeat (3) (*b*) above for equipment now placed into operation.

(6) Adjust equipment on a system basis as follows:
  (*a*) Adjust video levels (par. 97).
  (*b*) Measure the system signal-to-noise ratio (par. 100).

Section III. LUBRICATION AND WEATHERPROOFING

126. Lubrication Instructions

a. The motor bearings on the klystron drive motor should be lubricated at least once every 6 months and more frequently when operating in tropical or desert areas.

b. To lubricate the bearings, apply 4 drops of Oil, General Purpose, Low Temperature Lubricating per MIL–L–7870A to the two red holes on the top of the motor (fig. 117).

127. Weatherproofing

a. General. Signal Corps equipment, when operated in tropical, arctic, or desert regions, requires special treatment and maintenance. Fungus growth, insects, dust, corrosion, salt spray, excessive moisture, and extreme temperatures are harmful to most materials.

b. Tropical Maintenance. A special moistureproofing and fungiproofing treatment has been devised which, if properly applied, provides a reasonable degree of protection. This treatment is explained in TB SIG 13 and TB SIG 72. The equipment is given the moistureproofing and fungiproofing treatment at the factory and it is necessary to apply the treatment only when parts are replaced or repaired.

c. Winter Maintenance. Special precautions necessary to prevent poor performance or total operational failure of equipment in extremely low temperatures are explained in TB SIG 66 and TB SIG 219.

d. Desert Maintenance. Special precautions necessary to prevent equipment failure in areas subject to extremely high temperatures, low humidity, and excessive sand and dust are explained in TB SIG 75.

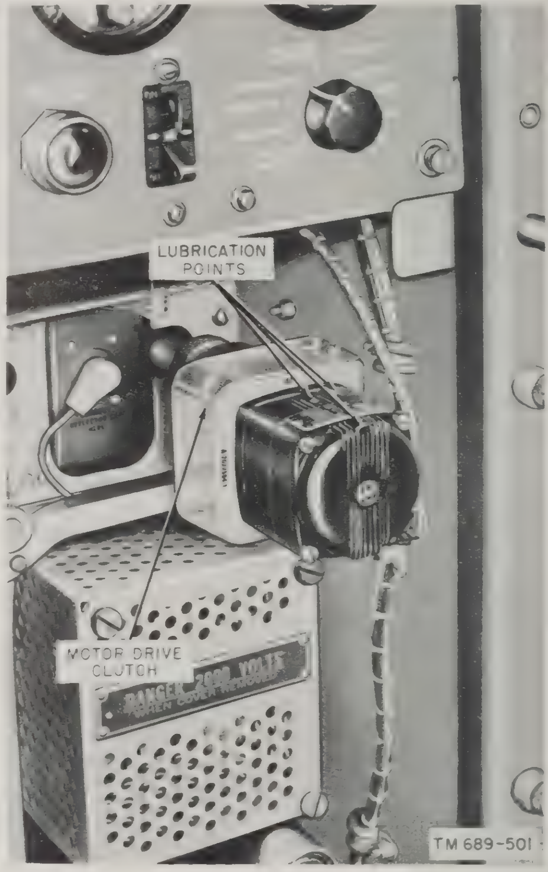


Figure 117. Klystron drive motor lubrication points.

Section IV. TROUBLESHOOTING AT ORGANIZATIONAL MAINTENANCE LEVEL

128. Test Equipment Recommended for Organizational Maintenance

a. General. Radio Set AN/TRC–29 has the following built-in test facilities: METER A and METER B in the radio transmitter, METER A and METER B in the radio receiver, PEAK VTVM meter, LINE VOLTS meter, and meters on the order-wire receiver and order-wire transmitter. The additional test equipment recommended is listed in *b* below. If these test instruments are not available, other types that have equal accuracy and similar characteristics may be used.

b. Test Equipment.

Quantity	Test equipment authorized issue at organizational level
1	Multimeter TS–352/U.
1	Electron Tube Test Set TV–7/U.

129. Radio Set AN/TRC–29 Trouble Localization

a. General.

(1) The procedure for localizing trouble to a station will, generally, also locate trouble in the receiver or transmitter. However, if this information is not available, use the procedure given in this chapter to find the defective equipment at a station.

(2) The scope of the procedures outlined in this chapter is limited to a failure of one of the following major equipments (or the components thereof) at the station:

- (*a*) Primary power equipment.
- (*b*) Transmitter equipment.
- (*c*) Receiver equipment.
- (*d*) Antenna equipment.

(3) The localization procedure is as follows:

- (*a*) Localize the trouble to one of the major equipments.
- (*b*) Replace the faulty AN/TRC–29 with the spare AN/TRC–29.
- (*c*) With the faulty equipment out of the traffic circuit, further localize the trouble to a component in one of the major equipments. Follow the procedures given in *b* through *f* below, and in the equipment performance check-list (par. 132).

b. Major Equipments. Several simple deductions can be made to determine quickly which major equipment (primary power, transmitter, receiver, or antenna) is at fault. The following indications will point to a failure in the major equipment under which they are listed:

(1) *Primary power equipment.*

- (*a*) All front panel pilot lights off.
- (*b*) LINE VOLTS meter on transmitter front panel reading zero.
- (*c*) INPUT POWER BREAKER circuit breakers on rear subpanel of the transmitter, high-voltage power supply in ON position.

(2) *Transmitter equipment.*

- (*a*) TRANSMITTER OPERATING light on front panel of Radio Transmitter T–303/G not lighted.
- (*b*) AFC CORRECTION+ or AFC CORRECTION– reading on METER A indicating more than 5.
- (*c*) Frequency, as indicated on WAVEMETER, more than 1.0 mc difference from last logged reading.

(3) *Receiver equipment.*

- (*a*) Alarm buzzer sounding in Order-Wire Receiver R–543/TRC–29.

  Note. If the receiver equipment has failed, this alarm will sound. However, it will also sound if the antenna is defective. Therefore, consider the possibility of either receiver or antenna failure when the audible alarm is heard.
- (*b*) Inability to call out from a station on an order-wire channel.

(4) *Antenna equipment.* Audible alarm in order-wire receiver is heard. Refer to the note in (3) (*a*) above.

c. Component Within Primary Power Equipment.

(1) Check the 115V or 230V circuit breaker of the autotransformer, whichever source is being used.

- (*a*) If it is turned on, proceed to (2) below.
- (*b*) If it is turned off, a short may exist in the autotransformer or in the cables between the autotransformer and the radio equipment or in the switchbox. Disconnect the input cable to the autotransformer and check the autotransformer, cables, and switchbox for a short circuit.

(2) Check the ac voltage at the OUTPUT VOLTAGE TEST jacks on the autotransformer.

- (*a*) If correct voltage (nominally 115 volts ac is obtained, proceed to (3) below.
- (*b*) If no voltage is obtained, check the voltage at the source. If the source voltage is correct, disconnect cable CX–2442/U (10 ft) from the source and the input of the autotransformer, and check the cable for continuity.

(3) Disconnect the output cable of Switch Box SA–357/G at the 115/230V OUTPUT receptacle, and check the voltage between pins D and E on the connector.

- (*a*) If the correct voltage (nominally

115 volts) is obtained, check cable CX–2440/U (150 ft), between the switchbox and radio equipment, for continuity.

(*b*) If no voltage is obtained, disconnect cable CX–2440/U (15 ft) from the 4 KVA MAX LOAD 115V OUTPUT connector on the autotransformer, and check the cable and switchbox for continuity.

d. Component Within Transmitting Equipment. The transmitting equipment contains four components: Power Supply PP–764/G, Power Supply PP–689/G, Radio Transmitter T–303/G, and Order-Wire Transmitter T–389/-TRC–29. These components can be checked as follows:

(1) *Power Supply PP–764/G.* This power supply can be assumed to be operating properly if the following radio transmitter meter readings are obtained:

(*a*) In REFL V position, METER A reads between 70 and 100 (item 25, par. 132*a*).

(*b*) In BEAM V position, METER A reads between 97 and 103 (item 15, par. 132*a*).

(*c*) In PA PLATE V position, METER B reads between 50 and 90 (item 29, par. 132*a*).

(2) *Power Supply PP–689/G.* This power supply can be assumed to be operating properly if the following radio transmitter meter readings and measured voltage are obtained:

(*a*) In +300 V position, METER B reads between 95 and 105 (item 13, par. 132*a*).

(*b*) In +250V position, METER B reads between 95 and 105 (item 12, par. 132*a*).

(*c*) In +150V position, METER B reads between 95 and 105 (item 11, par. 132*a*).

(*d*) In —150V position, METER B reads between 95 and 105 (item 9, par. 132*a*).

(*e*) With the multimeter, measure the voltage between terminal 6 of TB2 in the power supply and ground. A reading of +42 ±5 volts should be obtained (item 13A, par. 132*a*).

(3) *Radio Transmitter T–303/G.* Generally, a failure in the radio transmitter is shown by the TRANSMITTER OPERATING lamp being off and by one or more improper meter readings. Therefore, the first step in localizing trouble to the radio transmitter is to check its meter readings by procedure outlined in paragraph 132*a*. If the only indication of transmitter equipment failure is that the TRANSMITTER OPERATING lamp is off, the trouble may be in either the radio transmitter or the order-wire transmitter. To localize the trouble between these two units, proceed as follows:

(*a*) Turn on the transmitter equipment and check the reading CARR LIM GRID on the order-wire transmitter meter. If the reading is between 80 and 120, the trouble is still indefinite; proceed to (*b*) below. If no reading is obtained, or the reading is outside the normal limits, the trouble is in the order-wire transmitter.

(*b*) Disconnect Cord CG–409C/U (2 ft 6 in.) from the ORDER WIRE CARRIER OUTPUT receptacle, on the rear of the order-wire transmitter.

(*c*) Disconnect Cord CG-409C/U (1 ft 7 in.) from the VIDEO INPUT FROM REC receptacle, on the rear of the order-wire receiver.

(*d*) Connect a spare Cord CG–409C/U (25 ft) between the ORDER WIRE CARRIER OUTPUT, on the order-wire transmitter, and the VIDEO INPUT FROM REC on the order-wire receiver.

(*e*) Turn on the receiver equipment and wait 1 minute for the equipment to warm up. The alarm buzzer should sound until the equipment has warmed up.

(*f*) If, after 1 minute, the alarm buzzer in the order-wire receiver still sounds, the trouble is in the order-wire transmitter.

(4) *Order Wire Transmitter T–389/TRC–29.* Trouble in the order-wire

transmitter has been localized as instructed in (3) above.

e. Component Within Receiving System. The receiving equipment contains three components: Power Supply PP–690/G, Radio Receiver R–418/G, and Order-Wire Receiver R–543/TRC–29. A checking procedure for these components is given below.

(1) *Power Supply PP–690/G.* This power supply can be assumed to be operating properly if the following radio receiver meter readings and measured voltages are obtained:

(*a*) In BEAM V position, METER A reads between 90 and 100 (item 11, par. 132*b*).

(*b*) In +250V position, METER B reads between 95 and 110 (item 8, par. 132*b*).

(c) In +150V position, METER B reads between 95 and 110 (item 9, par. 132*b*).

(*d*) With the multimeter, measure the voltage between terminal 4, TB3, and ground. A reading of +42 ±5 volts should be obtained (item 9A, par. 132*b*).

(*e*) With the multimeter, measure the voltage between terminal 7, TB3, and ground. A reading of −625 ±10 volts should be obtained (item 9C, par. 132*b*).

(*f*) With the multimeter, measure the voltage between terminal 6, TB3, and ground. A reading of −475 ±8 volts should be obtained (item 9B, par. 132*b*).

(2) *Radio Receiver R–418/G.* Generally, a failure in the radio receiver is indicated by the sounding of the alarm buzzer and by one or more improper meter readings. To localize trouble to either the radio receiver or the order-wire receiver, follow the procedure outlined in the receiver equipment checklist (par. 132*b*).

(3) *Order Wire Receiver R–543/TRC–29.* Trouble in the order-wire receiver has been localized as instructed in (2) above.

f. Components Within Antenna System. Check for a faulty antenna system and take the necessary indicated corrective measures.

130. Troubleshooting Radio Frequency Transmission Line Assembly CG–1013/U

Open or short circuits, or bad connections are the only sources of equipment failure likely to occur in this equipment. Check all electrical connections for tightness and check all cable assemblies for possible open or short circuits.

a. No Rf Output. Lack of rf output usually is caused by a short or an open circuit in the rf components of the surface-wave transmission line. Check the rf cable assemblies for open and short circuits. Use an ohmmeter for making continuity checks, and use a megohmmeter for insulation tests. Multimeter TS–352/U may be used for these checks. Check the connector assembly and connecting rods for grounds.

b. No Heating Current. Lack of heating current usually is caused by an open circuit in the power cable assemblies, a blown fuse, or a defective de-icing transformer. Check the fuse on the de-icing transformer front panel. Check the power cable assemblies for open circuits and check all electrical connections for looseness and corrosion. Check the ac voltage output of the de-icing transformer. If there is no output, check the de-icing transformer for an open circuit. If an output is present, but the ammeter shows no reading, check the secondary of the current transformer and the ammeter for open circuits.

c. Low or Unstable Heating Current. Low or unstable heating current usually is caused by a loose connection. Check all electrical connections for looseness or corrosion.

d. Excessive Condensation Inside Launching Unit. Check the heating unit in the large end of the cone for a break in the Nichrome ring.

131. Troubleshooting by Using Equipment Performance Checklist

a. General. This paragraph contains the purpose and use of the equipment performance checklist (par. 132). It includes procedures that should be followed and tests that must be performed to use this table properly.

b. Purpose and Use.

(1) *Purpose.* The equipment performance checklist (par. 132) aids the operator

in locating trouble in the equipment.

(2) *When checklist is used.* The equipment performance checklist is used whenever equipment has failed or when meter readings are obtained, in preventive maintenance procedures, that fall beyond the specified limits.

(3) *How checklist is used.* The equipment performance checklist gives the items to be checked, the conditions under which each item is checked, the normal indications, and the tolerances of correct operations, any other conditions that may affect the normal reading, corrective measures that the operator may take, and any other measures that may be required to place equipment into operation. The use of each column in this checklist is described in (*a*) through (*f*) below.

(*a*) *Item No. column.* To use this list, follow the items in the numerical sequence that are indicated in the *Item No. column.*

(*b*) *Item action, or condition column.* For some items, the information given in this column consists of various switch and control settings under which the item or meter reading is to be checked. For other items, it represents an action that must be taken to check the normal indication given in the *normal indications column.*

(*c*) *Normal indications column.* The *normal indications* that are listed include the visible and audible signs that the operator should obtain when checking the items. If the indications are not normal, under the conditions listed in the *other conditions* column (when applicable), the operator should apply the recommended corrective measures.

(*d*) *Other conditions column.* For some items, the normal indication that is obtained is a function of certain other conditions, as listed in *other conditions* column.

(*e*) *Corrective measures column.* The corrective measures that are listed are those that the operator can make without turning in the equipment for repairs. A reference in the table to chapter 7 shows that troubleshooting by an experienced repairman is necessary. Observe the precautions and procedures outlined in *c* below when making these corrective measures.

(*f*) *Other measures column.* After the trouble has been corrected, perform any measures listed in the *other measures* column.

c. Procedures and Precautions. The following procedures and precautions should be observed when using this checklist:

(1) If possible, work should be performed on the equipment while it is being used as a spare set so that communications are not interrupted.

(2) When there are several meter readings or indications that require corrective actions, follow the sequence indicated by the item number in the first column of the table.

(3) Corrective measures for each meter reading or indication should be performed one at a time and the meter reading observed each time, in the sequence indicated (left to right, top to bottom) in the table. If a proper meter reading is obtained at any point, no further corrective measures should be taken except those indicated in the *other measures* column.

(4) Generally, the equipment performance checklist will be used by both organizational and field maintenance personnel to localize a defective stage or series of stages. For organizational personnel, maintenance in a stage involves checking and replacement of all removable items, usually just tubes. If the trouble cannot be remedied by organizational personnel, the stage should then be checked by field maintenance personnel who can check and replace, if necessary, all components in the stage following the procedures outlined in chapter 7.

(5) When a number of stages are to be checked, use the following procedure:

(*a*) Check the tubes, one at a time, in the tube tester, and replace the tubes that are found to be defective (par. 133). Return to the sockets from which they were removed the tubes that are found to be good.

(*b*) Follow any special procedures that are indicated in the checklist.

(6) After a trouble is corrected, the corrective action that is taken should be listed in the *remarks column* of the meter reading chart (par. 99). List a new meter reading in the *reading obtained at installation or after corrective maintenance* column of this chart.

(7) If a trouble has not been corrected after performing the operations given in this table, refer to chapter 7 for further corrective maintenance procedures. Generally, the following types of trouble are not corrected by this table:

(*a*) Trouble caused by an element that cannot be easily removed.

(*b*) Replacement of any discriminator circuit components (special test equipment is required for servicing these stages).

(*c*) Alinement of any of the if. amplifiers (special test equipment is required).

(*d*) Meter circuits (in some cases, special test equipment is required to determine whether the fault is due to the equipment or the metering circuit).

d. Special Test When IF. LEVEL Meter Reading is Low.

(1) *General.* If the IF. LEVEL meter reading is low, the cause of trouble may be due to low transmitter output at a previous station, trouble in the antenna components, an extremely deep fade, or trouble in the receiver input circuits. When substitution of the spare set corrects the meter reading, the trouble is in the radio receiver. If the same meter reading is obtained after substitution, check the meter again after 45 minutes. If the meter reading is still low, the trouble is probably in either the previous radio transmitter or the antenna system. Check the transmitter as described in the equipment performance checklist (par. 132). Check the antenna system.

(2) *Special test and check of if. amplified.* When the receiver is at fault, the trouble must still be localized between the preselector and the if. amplifier. (It is assumed that the local oscillator is operating properly, as determined by the proper WAVEMETER setting and the IF. MIXER reading.) To localize the trouble between these two units, proceed as follows:

(*a*) Place the POWER switches in both the receiver and the transmitter in the ON position. Allow a 15-minute warmup period.

(*b*) Connect the 20-db Radio Frequency Cable RG–21A/U, which is stored on the rear protective cover of the radio transmitter, to the receiver rf cable. This cable provides the preselector primary with a 50-ohm termination.

(*c*) Place the righthand meter selector switch of the radio receiver to the IF. MIXER position.

(*d*) Adjust the preselector carriage TUNING control clockwise (increasing cavity resonant frequency), and note the meter reading. At some point, the meter reading should drop sharply as the preselector becomes tuned to the local oscillator frequency. If it does, the preselector is operative. Otherwise, the trouble is in the preselector and it must be replaced (ch. 7).

(*e*) Disconnect the 20-db cable and connect the receiver rf cable to the RF INPUT jack on back of the radio receiver.

(*f*) Connect the 3-foot Radio Frequency Cable RG–9B/U between the RF TEST OUTPUT jack on back of the radio transmitter and the ANT. jack on back of the radio receiver.

(*g*) Retune the local oscillator to a frequency 120 mc above that of the transmitter in operation, according to the procedure outlined in paragraph 81.

(*h*) Tune the preselector to this new carrier frequency as follows:
  1. Place the METER A selector switch in the radio receiver in the IF. LEVEL position.
  2. Adjust the preselector carriage TUNING control for a maximum meter reading.
  3. Detune the preselector primary cavity by moving the shorting plunger to its upper position.
  4. Adjust the preselector carriage TUNING control for a maximum meter reading.
  5. Drop the primary shorting plunger to its lower position, and place the secondary shorting plunger in its upper position.
  6. Adjust the vernier tuning screw under the primary cavity for a maximum meter reading. Drop the secondary plunger to its lower position.
  7. Repeat the steps in *3* through *6* above.

(*i*) Place the left hand meter selector switch in the IF. LEVEL position.

(*j*) Turn the IF. LEVEL control fully clockwise.

(*k*) Remove the first IF. preamplfier, VI. Check it in a tube tester. If it is defective, replace it with a new tube and note the change in the meter reading.

(*l*) Repeat the step in (*k*) above for tubes V2 through V12 (all tubes in the if. preamplifier and if. amplifier). Note the IF. LEVEL meter reading.

(*m*) When an IF. LEVEL meter reading above 125 is not obtained, refer to chapter 7.

(*n*) Disconnect the cable from the radio transmitter to the receiver ANT. jack.

(*o*) Tune the preselector to the operating carrier frequency (par. 82).

(*p*) Tune the local oscillator to its operating frequency (par. 83).

(*q*) During the next preventive maintenance period, connect this equipment to the antenna and retune the preselector (par. 91). Compare the IF. LEVEL meter reading that is obtained on this unit with the reading obtained on the operating equipment. If it compares, the trouble has been repaired. Otherwise, it may be necessary to realine the if. amplifier. Refer to chapter 7 for this procedure.

132. Equipment Performance Checklists

a. Transmitter Equipment Performance Checklist. Before proceeding with the chart given below, place the following power switches in the OFF position: FIL and PLATE in the order-wire transmitter; POWER in the radio transmitter; and HV FILAMENT, BIAS V —150V, LV PLATE, KLYSTRON HV, and PA PLATE in the high-voltage power supply. Be sure that all the interlock switches are closed and that all other controls are set as indicated in paragraph 95. Figures 118 through 135 show tube locations.

	Item No.	Item, action, or condition	Normal indication	Other condition	Corrective measures	Other measures
PREPARATORY	1	Cables	Check to see that connections are proper and secure (par. 55 through 63).			
	2	Protective covers on racks.	All covers are securely in place and interlock switches are closed.			
	3	Controls	Set to proper position (par. 95), except power switches noted above.			

	Item No.	Item, action, or condition	Normal indication	Other condition	Corrective measures	Other measures
PREPARATORY	4	LINE VOLTS meter on radio transmitter.	Between 103.5 and 126.5	INPUT POWER BREAKERS in ON position. If either or both circuit breakers are OFF, reset them.	If circuit breakers stay in ON position, check CB1 and CB2 in high-voltage supply and primary power lines (par. 129). If circuit breakers keep opening, refer to chapter 7.	

	Item No.	Item, action, or condition	Normal indication	Other condition	Corrective measures	Other measures
START	5	Place POWER switch in ON position.	POWER ON lamp in high-voltage power supply should go on. All filaments in radio transmitter, plus V11 filament in high-voltage power supply, should go on.	Circuit breaker stays in ON position. If it keeps opening, refer to chapter 7	Check CB1 in radio transmitter, and I 1 in high-voltage power supply.	
	6	Place HV FILAMENT switch in ON position.	Filaments in high-voltage supply should go on.	Circuit breaker should stay in ON position.	If circuit breaker keeps opening, remove and replace (one at a time) all tubes, except V11, from high-voltage supply. Reset circuit breaker to ON position each time a tube is removed and replaced, until circuit breaker stays on or all tubes have been removed. If removal of one tube corrects trouble, replace that tube with a new one. If circuit breaker stays on, but filaments do not, light, check CB3.	
	7	Place LV FILAMENT switch in ON position.	FIL ON lamp and all filaments in low-voltage power supply should go on.	Circuit breaker stays in ON position.	If circuit breaker keeps opening, remove tubes in low-voltage power supply; one at a time; follow the procedure outlined in item 6 above. If circuit breaker stays in ON position, check CB4 in high-voltage power supply and I 1 in low-voltage power supply.	
	8	Place FIL switch in order-wire transmitter in ON position.	Filaments in order-wire transmitter should go on.	Circuit breaker stays in ON position.	If circuit breaker keeps throwing, remove tubes in order-wire transmitter, one at a time; following procedure outlined in item 6. If circuit breaker stays in ON position, check CB2 in order-wire transmitter.	

START

Item No.	Item, action, or condition	Normal indication	Other condition	Corrective measures	Other measures
9	Place BIAS V −150V switch in high-voltage power supply in ON position.	−150V setting on METER B in radio transmitter should read between 95 and 105 after a warm-up of about 15 minutes.		Check stages V16 and V15 in low-voltage power supply, and relays K1 and K2 in high-voltage power supply.	
10	Place LV PLATE switch in high-voltage power supply in ON position.	LV PLATE ON lamp in low-voltage power supply should light.	Circuit breaker stays in ON position.	If circuit breaker keeps throwing, refer to chapter 7.	
				If circuit breaker stays in ON position, check I 2 in low-voltage power supply and CB6 in high-voltage power supply.	
11	+150V switch setting on radio transmitter (METER B).	95 to 105	Adjust +150V ADJ. control in low-voltage power supply from one extreme position to the other. If meter reading varies over a range of at least plus and minus 5 divisions, readjust control for reading obtained during installation (par. 99). Otherwise perform corrective measures indicated in next column.	Check stages V13, V11, V10, V4, V5, and V6 in low-voltage power supply (+150-volt supply).	Adjust +150V ADJ. control for reading obtained during installation. Refer to chapter 7 if reading is not known.
12	+250V switch setting on radio transmitter (METER B).	95 to 105	Same as item 11, with +250V ADJ. control in low-voltage power supply.	Check V9, V7, and V8 in low-voltage power supply (+250-volt supply).	Adjust +250V ADJ. control for reading obtained during installation. Refer to chapter 7 if this reading is not known.
13	+300V switch setting on radio transmitter (METER B).	95 to 105	Same as item 11, with +300V ADJ. control in low-voltage power supply.	Check stages V3, V2, and V1 in low-voltage power supply (+300-volt supply).	Adjust +300V ADJ. control for reading obtained during installation. Refer to chapter 7 if this reading is not known.
13A	Measure voltage between terminal 6, TB2, and ground in low-voltage power supply.	+42 volts, ±5		Check stage V14	

	Item No.	Item, action, or condition	Normal indication	Other condition	Corrective measures	Other measures
START	14	Place KLYSTRON HV switch on high-voltage power supply in ON position.	HV PLATE ON lamp and blower should go on.	Circuit breaker should stay in ON position and blower motor should operate. If blower does not operate, place KLYSTRON HV switch in OFF position, and refer to chapter 7.	If circuit breaker keeps throwing refer to chapter 7. If circuit breaker stays in ON position, check CB7, and I 2 in high-voltage power supply.	
	15	BEAM V switch setting on radio transmitter (METER B).	97 to 103	Same as item 11, with BEAM V ADJ. in high-voltage power supply.	Check stages V7, V3, V5, V6, V8, V1, and V2 (beam-voltage supply) in high-voltage power supply.	Adjust BEAM V ADJ. control for reading obtained during installation. Refer to chapter 7 if this reading is not known.
	16	Place PA PLATE switch on high-voltage power supply in ON position.	Circuit breaker stays in ON position.		Refer to chapter 7.	
	17	Place PLATE switch on order-wire transmitter in ON position.	+140V meter setting on order-wire transmitter should be between 90 and 110.	Circuit breaker stays in ON position. Same as item 11, with +140V ADJ. control in order-wire transmitter.	If circuit breaker keeps opening, follow procedure outlined in item 8. If circuit breaker stays in ON position, check stages V11, V10, and V9 (+140-volt supply), CB1 in order-wire transmitter, and CB8 in high-voltage power supply.	Adjust +140V ADJ. contro for reading obtained during installation. Refer to chapter 7 if this reading is not known.

	Item No.	Item, action, or condition	Normal indication	Other condition	Corrective measures	Other measures
EQUIPMENT PERFORMANCE	18	AFC 1ST MULT GRID switch setting on radio transmitter (METER A).	Above 40		Check stage V11 (crystal multiplier chain).	Retune crystal multiplier chain (par. 76).
	19	AFC MIXER switch setting on radio transmitter (METER A).	Above 28		Check stage V12 (tripler).	Same as item 18.
	20	WAVEMETER switch setting on radio transmitter (METER B).	Above 30	WAVEMETER setting adjusted for peak reading, and KLYSTRON POWER OUT meter reading normal (item 26).	Check wavemeter crystal CR4.	

	Item No.	Item, action, or condition	Normal indication	Other condition	Corrective measures	Other measures
EQUIPMENT PERFORMANCE	21	WAVEMETER setting.	Less than 2.0 mc difference from setting obtained during installation. (Refer to chart for wavemeter calibration).	AFC CORRECTION+ and CORRECTION− reading average 0 ±5 (item 22), and 1ST LIM GRID (item 23) reading obtained.	Refer to chapter 7.	
	22	AFC CORRECTION+ and CORRECTION− switch settings on radio transmitter (METER A).	Average of two readings should not exceed five.	Frequency off by more than 2 mc as noted in item 21, and average reading over 15.	Check relay K1, stages V23, V24, V25, and V26 (chopper amplifier), and afc motor system in radio transmitter.	
	23	1ST LIM GRID switch setting on radio transmitter (METER A).	Above 20	AFC MIXER meter reading normal (item 24).	Check stages V13 to V18 (if. amplifiers) in radio transmitter.	Observe if. amplifier precautions indicated in par. 131d(2).
	24	AFC MIXER switch setting on radio transmitter (METER A).	Above 28	KLYSTRON POWER OUT meter reading normal (item 26).	Check CR1 (afc-mixer crystal) in radio transmitter.	Same as item 18.
	25	REFL V switch setting on radio transmitter (METER A).	Within 80 to 120% of reading recorded after installation.	Check tuning of klystron and power amplifier (par. 77).	Check stages V9, V10, and V8 (electronic voltage regulator) in radio transmitter, and V9 and V10 in high-voltage power supply.	Retune klystron and power amplifier (par. 77).
	26	KLYSTRON POWER OUT switch setting on radio transmitter (METER A).	Above 60% of reading obtained after installation.	PA GRID CUR. meter reading proper (item 27).	Check CR3 in radio transmitter (double coupler).	Tune klystron and power amplifier (par. 77).
				PA GRID CUR. meter reading low (item 27). Check tuning of klystron and power amplifier (par. 77).	Replace klystron V38 (par. 133).	
	27	PA GRID CUR. switch setting on radio transmitter (METER B).	Above 28	PA CATH CUR. meter reading normal (item 27).	Check stub tuner and double-coupler cable connections.	Retune klystron and power amplifier (par. 77).
	28	PA CATH CUR. switch setting on radio transmitter (METER A).	100	Check to see if adjustment of VARIABLE AUTOTRANSFORMER control on high-voltage power supply will result in reading of 100.	Replace V37 (power amplifier) (par. 133c).	Retune klystron and power amplifier (par. 77).
				PA PLATE V meter reading proper or high (item 25).		

Item No.	Item, action, or condition	Normal indication	Other condition	Corrective measures	Other measures
29	PA PLATE V switch setting on radio transmitter (METER B).	50 to 100	PA CATH CUR. meter reading 100.	Check stage V11 in high-voltage power supply.	
30	PEAK VTVM switch setting on radio transmitter, with switch in either NEG PEAK or POS PEAK position (par. 97*b*).	0	VTVM SEL SW in GND position. Adjust VTVM ZERO BAL POS or VTM ZERO BAL NEG control so that meter reads off zero and then to zero.	Check stage V32 (vtvm dc amplifier).	
31	Connect Cord CG-409 C/U between VIDEO OUT-PUT MONITOR receptacle, on back of operating receiver, and VIDEO INPUT receptacle, on back of radio transmitter under test. PEAK VTVM meter adjusted as in item 30.	Ratio $\frac{\text{MOD OUT}}{\text{MOD IN}}$ within 10% of ratio obtained after installation.	VTVM SEL SW placed first in MOD OUT position and then in MOD IN position.	Check stages V1 to V6 (modulator) in radio transmitter.	
32	PEAK VTVM switch setting on radio transmitter, with VTVM SEL SW in MON OUT position.	Ratio $\frac{\text{MON OUT}}{\text{MOD OUT}}$ within 10% of ratio obtained after installation.	Check REFL. VOLTS ADJUST for minimum deviation sensitivity (par. 77*b*(49) and (50)).	Check stage V22 (video preamplifier) in radio transmitter.	
33	ORDER WIRE CARR LEVEL switch setting on radio transmitter (METER B).	Above 80% of reading obtained after installation	CARR LIM GRID meter reading proper. Tune MON OW PLATE TUN control for maximum ORDER WIRE CARR LEVEL meter reading.	Check stages V34, V35, and V36 (monitor amplifiers) in radio transmitter (vtvm subchassis), and V4 (carrier amplifier) in order-wire transmitter.	Retune MON OW PLATE TUN control for maximum ORDER WIRE CARR LEVEL meter reading.
34	TRANSMITTER ON lamp.	Should be on	Try adjustment in item 33.	Check I 1, K4, and V36 in the radio transmitter.	Same as item 33.
35	CARR LIM GRID setting on order-wire transmitter.	Above 64		Check stages V2 and V3 (carrier oscillator and amplifier) in order-wire transmitter.	If V2 is replaced, adjust FREQ ADJ and MOD SENS ADJ by adjusting FREQ ADJ control for same average DISCR+ and DISCR− meter reading as shown by last logging.

	Item No.	Item, action, or condition	Normal indication	Other condition	Corrective measures	Other measures
EQUIPMENT PERFORMANCE						Then, with ORDER WIRE TEST SWITCH in THRUTONE, and meter selector switch in AUDIO, adjust MOD SENS ADJ control for reading obtained at last logging. Repeat the steps just given.
	36	DISCR+ and DISCR− meter setting on order-wire transmitter.	Average should be 0 ±10.		Refer to chapter 7	
	37	AUDIO meter setting on order-wire transmitter.	Above 56	ORDER WIRE TEST SWITCH in THRU TONE position. Same as meter reading obtained with switch in LOCAL TONE position (item 38).	Stage V5 (tone oscillator) in order-wire transmitter.	Adjust audio levels (par. 78*b*(1) through (3)).
	38	AUDIO meter setting on order-wire transmitter.	Above 56	ORDER WIRE TEST SWITCH in LOCAL TONE position. Proper meter reading obtained in item 37, or proper meter reading obtained in this item but not in item 37.	Stage V1 (audio amplifier) in order-wire transmitter.	Adjust audio levels (par. 78*b*(1) through (3)).

	Item No.	Item, action, or condition	Normal indication	Other condition	Corrective measures	Other measures
STOP	39	Place POWER switch in radio transmitter in OFF position.	All pilot lamps should go off.			

b. Receiver Equipment Performance Checklist. Before proceeding with the checklist given below, place the following power switches in the OFF position: FIL and PLATE in the order-wire receiver; POWER in the radio receiver; and HV FIL, LV FIL, and HV PL in the receiver power supply. Be sure that all interlock switches are closed and that all other controls are set as indicated (par. 95). Refer to figures 128 through 135 for tube locations.

	Item No.	Item, action, or condition	Normal indication	Other condition	Corrective measures	Other measures
PREPARATORY	1	Cables	Check to see that connections are proper and secure (par. 55 through 62).			
	2	Dust covers on back rack.	All securely in place and interlock switches closed.			
	3	Controls	Set to position, except power switches noted above (par. 95).			

	Item No.	Item, action, or condition	Normal indication	Other condition	Corrective measures	Other measures
START	4	Place POWER switch on radio receiver in ON position.	POWER ON lamp on receiver power supply should go on, and filaments in radio receiver should light.	INPUT POWER BREAKERS are in ON position and stay in this position.	Check CB1 in radio receiver, and I 2 in receiver power supply. If circuit breakers keep throwing, remove and replace, one at a time, all tubes in receiver power supply except V14 and V17. Reset circuit breaker to ON position each time a tube is removed until circuit breaker stays on or all tubes have been removed and replaced. If removal of one tube corrects trouble, replace that tube.	
	5	Place HV FIL switch on receiver power supply in ON position.	Filaments in receiver power supply should go on.	--------------------	Check tubes V14 and V17 in receiver power supply and V28 and V21 (do not remove V21, just disconnect its base); follow procedure outlined in item 4 above. If trouble is due to V21, replace it as described in paragraph 133*d*. If circuit breaker stays in ON position, but filaments do not light, check CB3 in receiver power supply.	Retune local oscillator (par. 83) if V21 is replaced.
	6	Place FIL switch in order-wire receiver in ON position.	Filaments in order-wire receiver should light.	Circuit breaker should stay in ON position.	If circuit breaker keeps throwing, remove tubes in order-wire receiver, one at a time, following procedure outlined in item 5. If circuit breaker stays in ON position, but filaments do not light, check CB1 in order-wire receiver.	

START

Item No.	Item, action, or condition	Normal indication	Other condition	Corrective measures	Other measures
7	Place LV PL switch in receiver power supply in ON position.	PLATE ON lamp should go on.	Circuit breaker stays in ON position.	If circuit breaker keeps throwing, refer to chapter 7. If circuit breaker stays on, check K1, I 1, and CB1 in receiver power supply.	
8	+250V switch setting on radio receiver (METER B).	Between 95 and 110 after 15-minute warmup period.	LINE VOLTS meter reading 115 volts ±4 volts. Adjust +250V ADJ. control, in receiver power supply, from one extreme position to the other. If meter reading varies over a range of at least 80 to 120, readjust control for reading obtained after installation. Otherwise, perform corrective measures indicated in next column.	Check stages V12, V13, V8, V9, V10, V11, V3, V2, and V1 in (+250-volt supply) receiver power supply.	Adjust +250V ADJ. control for reading obtained after installation. Refer to chapter 7 if this reading is not known.
9	+150V meter setting on radio receiver (METER B).	Between 95 and 110.	Same as item 8 using +150V ADJ. control in receiver power supply.	Check stages V5, V7, V3, and V4 (+150-volt supply) in receiver power supply.	Adjust +150V ADJ. control for reading obtained after installation. Refer to chapter 7 if this reading is not known.
9A	Measure voltage between terminal 4, TB3, and ground in receiver power supply.	+42 volts ±5		Check stage V6.	
9B	Place HV PL switch in ON position. Measure voltage between terminal 6, TB3, and ground in receiver power supply.	−475 volts ±8		Check stage V15.	
9C	Measure voltage between terminal 5, TB3, and ground in receiver power supply.	−625 volts ±20.		Check stage V17, V15, V16, V11, and V14.	

	Item No.	Item, action, or condition	Normal indication	Other condition	Corrective measures	Other measures
START	10	Place PLATE switch on order-wire receiver in ON position.	+140V meter reading on order-wire receiver between 90 and 110.	Circuit breaker stays in ON position.	If circuit breaker keeps throwing, remove V11, and reset circuit breaker. If it does not throw, check tubes V1 through V10 in tube checker for shorts. If breaker did throw, first remove tube V12 and then V13; reset circuit breaker each time, and note whether it throws. If it does not, tube removed should be replaced.	
				Same as item 8 with +140V ADJ. control on order-wire receiver.	If circuit breaker stays in ON position, but proper reading cannot be obtained, check stages V11, V13, V12, and V10 (+140-volt supply).	Adjust +140V ADJ. control for reading obtained after installation. Refer to chapter 7 if this reading is not known.
	11	Place HV PL switch on receiver power supply in ON position.	A BEAM V meter reading within five divisions of reading obtained during installation.	Circuit breaker stays in ON position.	If circuit breaker keeps throwing, refer to chapter 7.	
				Allow a 15-minute warmup period. Check BEAM CUR. meter reading (item 20). If both readings are low, refer to next column. If BEAM CUR. reading is low and BEAM V high, refer to item 20.	If circuit breaker stays on, check stage V16 (−300-volt supply), and CB2 in receiver power supply.	Adjust BEAM CURRENT control (in radio receiver) for BEAM CURRENT reading obtained after installation. If this reading is either not known or unobtainable, refer to chapter 7.

	Item No.	Item, action, or condition	Normal indication	Other condition	Corrective measures	Other measures
EQUIPMENT PERFORMANCE	12	AFC 1ST MULT GRID meter setting on radio receiver (METER B).	Above 24		Check stage V22 and crystal Y2 in radio receiver (crystal oscillator).	Retune crystal multiplier chain (par. 80).
	13	AFC 2ND MULT GRID meter setting on radio receiver (METER A).	Above 60		Check stages V22 and V23 in radio receiver.	Retune crystal multiplier chain (par. 80).

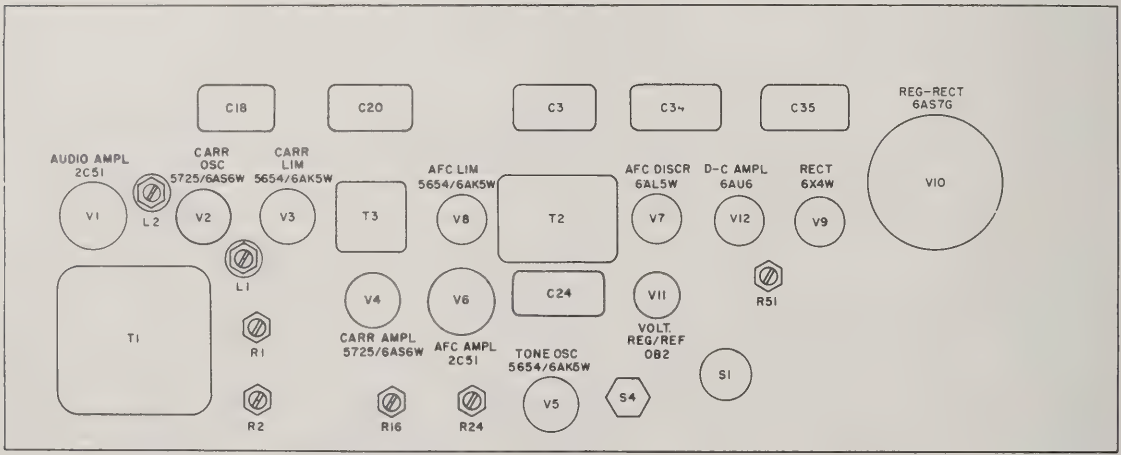
Item No.	Item, action, or condition	Normal indication	Other condition	Corrective measures	Other measures
14	AFC 3rd MULT GRID switch setting on radio receiver (METER B).	Above 40		Check stages V23 and V24 in radio receiver.	Retune crystal multiplier chain (par. 80).
15	WAVEMETER switch setting on radio receiver (METER A).	Above 30	WAVEMETER setting adjusted for peak reading and IF. MIXER reading is proper (item 22).	Check wavemeter crystal CR7 in radio receiver.	Loosen screw on klystron output connection labeled WVMTR, and adjust probe for meter reading of 50. Tighten set screw.
16	WAVEMETER setting different from setting obtained at installation. (See chart for wavemeter calibration.)	Less than 2.0 mc		Refer to item 17.	
17	AFC CORRECTION+ and AFC CORRECTION− switch setting on radio receiver (METER A).	Average of two readings should not exceed five.		Refer to chapter 7.	
			Frequency off more than 2.0 mc (item 16), and average reading over 15.	Check stage V28 (dc amplifier) in radio receiver.	Retune local oscillator (par. 83).
			Frequency off by more than 2 mc (item 16); AFC IF. LEVEL meter reading is correct (item 18), and average AFC CORRECTION meter reading is below 5.	Check stage V27 (3d afc if.), refer to chapter 7.	
18	AFC IF. LEVEL switch setting on radio receiver (METER B).	Above 48	AFC MIXER meter reading proper (item 19).	Check stages V25 and V26 in radio receiver.	
19	AFC MIXER meter switch setting on radio receiver (METER A).	Above 30	IF. MIXER meter reading proper (item 22).	Check stage V24 and crystal CR3 (final multiplier and mixer) in radio receiver.	Retune AFC MIX TUN control for maximum meter reading.
20	BEAM CUR. switch setting on radio receiver (METER A).	A meter reading of ±5 divisions from reading obtained at installation.	BEAM V reading high when BEAM CURRENT reading is low.	Adjust BEAM CURRENT control for reading obtained during installation. If BEAM V reading is still not proper, refer to chapter 7.	Retune local oscillator (par. 83).
21	REFL V switch setting on radio receiver (METER A).	A meter reading of ±5 divisions from reading obtained at installation.	Retune local oscillator (par. 83).	Check stage V28 (afc dc amplifier) in radio receiver.	Retune local oscillator (par. 83).

EQUIPMENT PERFORMANCE

Item No.	Item, action, or condition	Normal indication	Other condition	Corrective measures	Other measures
22	IF. MIXER switch setting on radio receiver (METER B).	Above 48	Retune local oscillator (par. 83).	Check crystal in preselector-mixer, and klystron V21 in radio receiver.	Retune local oscillator (par. 83).
23	IF. LEVEL meter setting on radio receiver (METER A).	Above 8	No signal input	Refer to paragraph 131*d*.	
24	IF. DISCR FREQ HIGH and IF. DISCR FREQ LOW switch setting on radio receiver (METER B).	Average 0 ±10	Rf signal picked up by this receiver is at proper frequency.	Refer to chapter 7.	
25	OW CARR LEVEL switch setting on order-wire receiver.	Above +40		Check stages V1, V2, V3, V7 and V4 (subcarrier amplifiers, limiters, and differential amplifier) in order-wire receiver.	
26	AUDIO switch setting on order-wire receiver following AUDIO LEVEL adjustment (par. 84*b*).	100	Order-wire transmitter level adjusted properly (par. 78).	Check stage V6 in order-wire receiver.	Readjust AUDIO LEVEL control. Refer to *Item, action, or condition* column.
27	ALM SENS control.	Cannot be adjusted as described in paragraph 84*b* (7).		Check stage V8 in order-wire receiver.	Adjust ALM SENS control (par. 84).
28	DISCR+ and DISCR− switch setting on order-wire receiver.	Average 0 ±20	Incoming signal at proper frequency.	Refer to chapter 7.	
29	DIV CONT LEVEL switch setting on both preferred and standby order-wire receivers.	Above 30	Equipment connected for diversity operation.	Check stages V8 and V9 in both preferred and standby receivers.	Adjust receivers for diversity operation (par. 93).
30	DIV OPER switch setting on operating order-wire receiver.	90 to 110	Equipment connected for diversity.	Check relay K1.	
31	DIV OPER meter setting in standby order-wire receiver.	0 ±3	Same as item 30	Check relay K1.	
32	Depress RING pushbutton on order-wire rereceiver.	A ring should be heard in both directions.	Voice communications normal.	Ring is not heard in either direction. Check diode CR6 and K3 in order-wire receiver.	

	Item No.	Item, action, or condition	Normal indication	Other condition	Corrective measures	Other measures
EQUIPMENT PERFORMANCE	33	Initiate call with other stations.	Alarm buzzer should be silent.	Ring and voice communications normal.	Ring is heard in one direction only. Check stage V4 in order-wire transmitter, for direction that ring is not heard in. If alarm buzzer sounds, although equipment is operating properly (meter readings proper and communications can be established), check V7 (differential amplifier), V8 (alarm relay control), and relay K2. Ring signals transmitted properly, but defect in voice modulation; check V1 (audio amplifier) in order-wire transmitter.	

	Item No.	Item, action, or condition	Normal indication	Other condition	Corrective measures	Other measures
STOP	34	Place POWER switch on radio receiver in OFF position.	All pilot lamps should go off.			


C18
C20
C3
C34
C35
REG-RECT 6AS7G
V10
AUDIO AMPL 2C51
V1
L2
CARR OSC 5725/6AS6W
V2
CARR LIM 5654/6AK5W
V3
T3
AFC LIM 5654/6AK5W
V8
T2
AFC DISCR 6AL5W
V7
D-C AMPL 6AU6
V12
RECT 6X4W
V9
L1
T1
R1
V4
V6
C24
V11
R51
CARR AMPL 5725/6AS6W
AFC AMPL 2C51
VOLT. REG/REF 0B2
TONE OSC 5654/6AK5W
S1
V5
S4
R2
R16
R24

TM 689-406

Figure 118. Order-wire transmitter, tube location diagram.

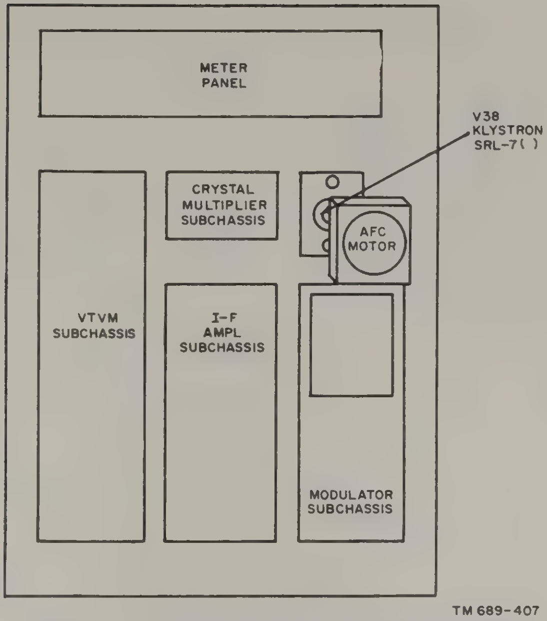

METER PANEL
V38 KLYSTRON SRL-7( )
CRYSTAL MULTIPLIER SUBCHASSIS
AFC MOTOR
VTVM SUBCHASSIS
I-F AMPL SUBCHASSIS
MODULATOR SUBCHASSIS
TM 689-407

Figure 119. Radio transmitter, main chassis, tube location diagram.

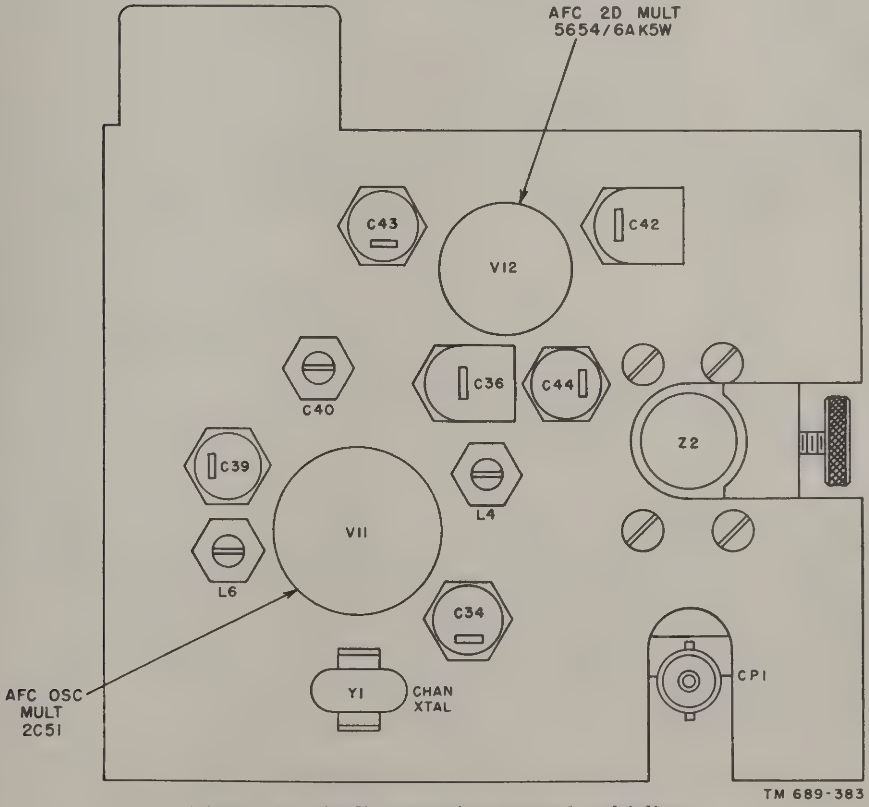

AFC 2D MULT 5654/6AK5W
C43
V12
C42
C40
C36
C44
Z2
C39
VII
L4
L6
C34
AFC OSC MULT 2C51
YI
CHAN XTAL
CPI
TM 689-383

Figure 120. Radio transmitter crystal multiplier, tube location diagram.

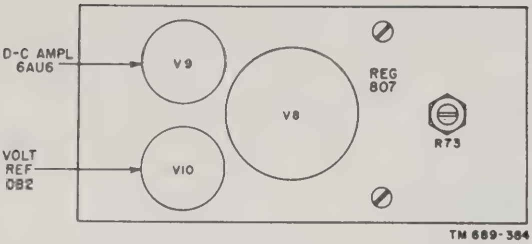

D-C AMPL
6AU6
VOLT
REF
0B2
V9
V10
V8
REG
807
R73
TM 689-384

Figure 121. Radio transmitter electronic voltage regulator, tube location diagram.

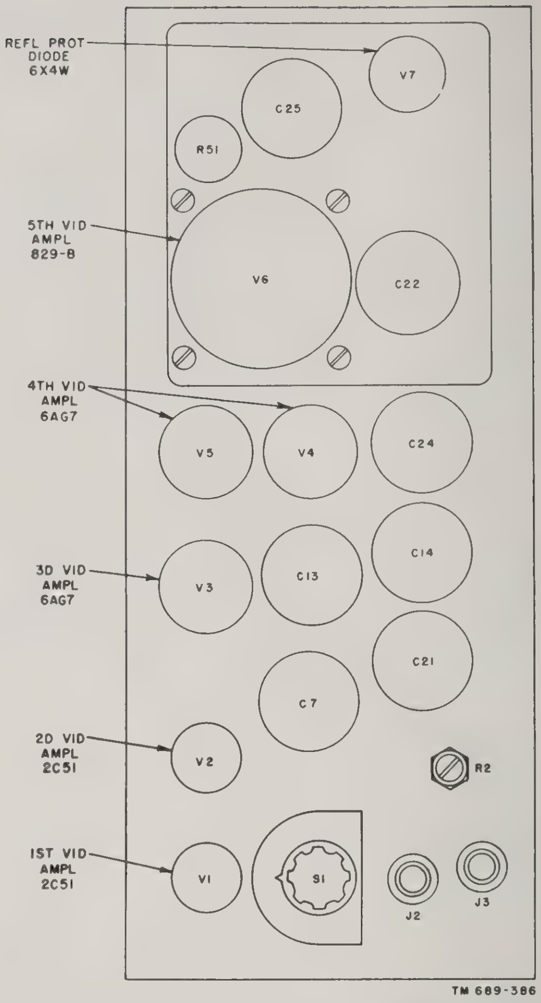

REFL PROT
DIODE
6X4W
V7
C25
R51
5TH VID
AMPL
829-B
V6
C22
4TH VID
AMPL
6AG7
V5
V4
C24
3D VID
AMPL
6AG7
V3
C13
C14
C21
C7
2D VID
AMPL
2C51
V2
R2
1ST VID
AMPL
2C51
V1
S1
J2
J3
TM 689-386

Figure 123. Radio transmitter modulator, tube location diagram.

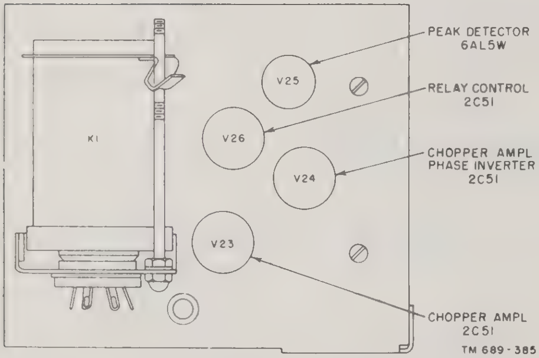

PEAK DETECTOR
6AL5W
V25
RELAY CONTROL
2C51
V26
K1
CHOPPER AMPL
PHASE INVERTER
2C51
V24
V23
CHOPPER AMPL
2C51
TM 689-385

Figure 122. Radio transmitter chopper, tube location diagram.

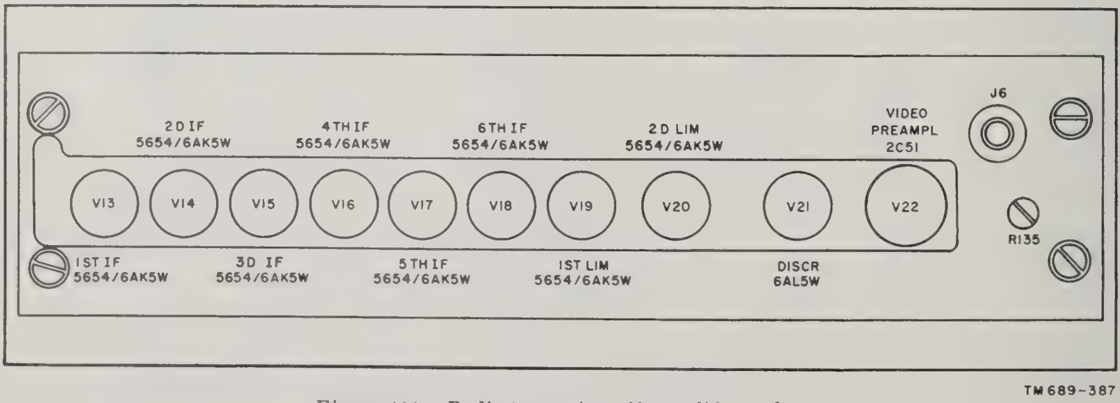

2D IF
5654/6AK5W
4TH IF
5654/6AK5W
6TH IF
5654/6AK5W
2D LIM
5654/6AK5W
VIDEO
PREAMPL
2C51
J6
V13
V14
V15
V16
V17
V18
V19
V20
V21
V22
R135
1ST IF
5654/6AK5W
3D IF
5654/6AK5W
5TH IF
5654/6AK5W
1ST LIM
5654/6AK5W
DISCR
6AL5W
TM 689-387

Figure 124. Radio transmitter if. amplifier, tube location diagram.

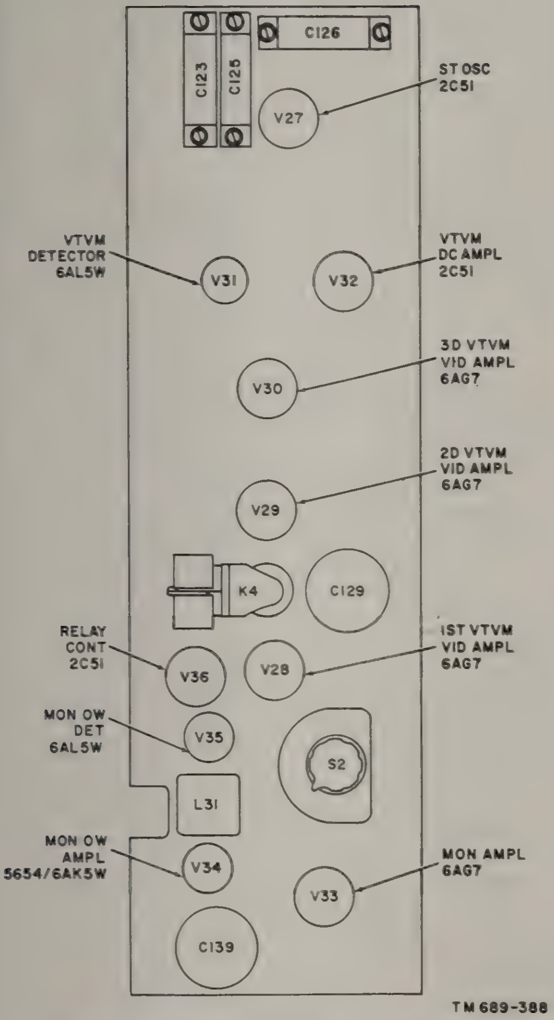

C123
C125
C126
ST OSC 2C51
V27
VTVM DETECTOR 6AL5W
V31
V32
VTVM DC AMPL 2C51
V30
3D VTVM VID AMPL 6AG7
V29
2D VTVM VID AMPL 6AG7
K4
C129
RELAY CONT 2C51
V36
V28
1ST VTVM VID AMPL 6AG7
MON OW DET 6AL5W
V35
S2
L31
MON OW AMPL 5654/6AK5W
V34
V33
MON AMPL 6AG7
C139
TM 689-388

Figure 125. Radio transmitter, vtvm, tube location diagram.

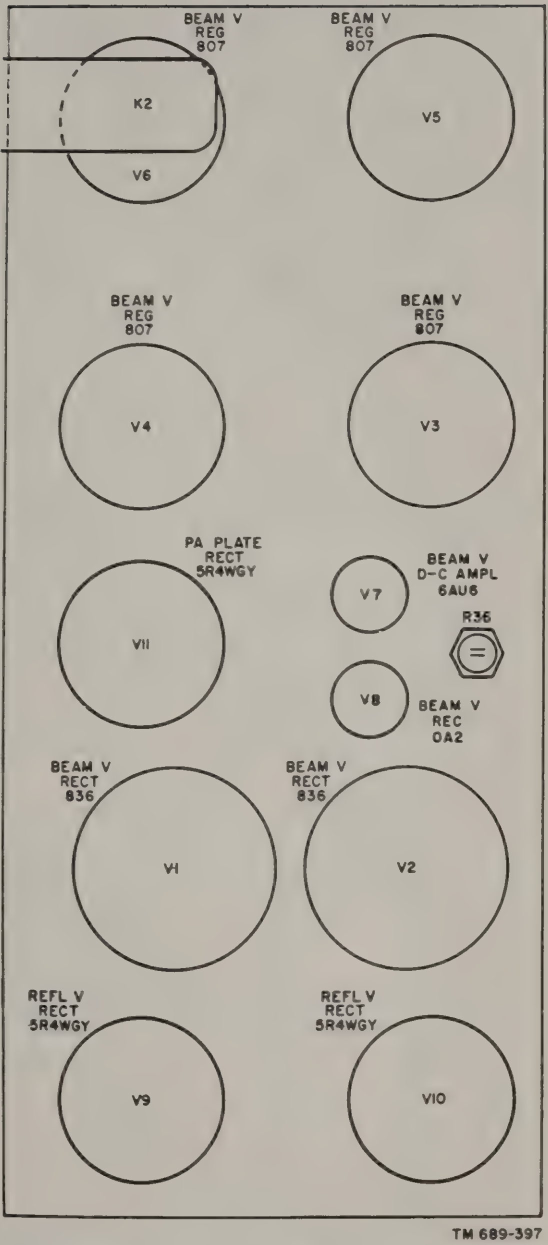
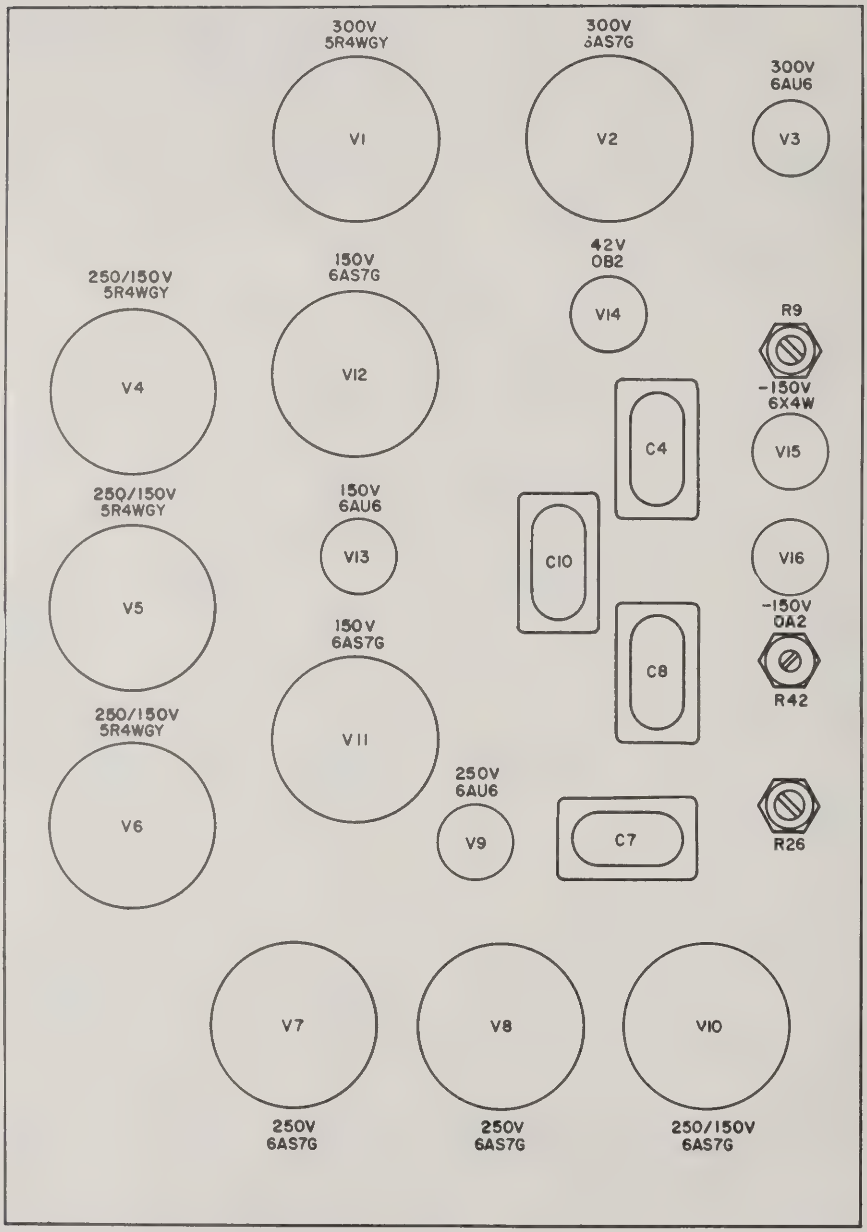

BEAM V REG 807
BEAM V REG 807
K2
V6
V5
BEAM V REG 807
BEAM V REG 807
V4
V3
PA PLATE RECT 5R4WGY
V11
BEAM V D-C AMPL 6AU6
V7
R36
V8
BEAM V REC OA2
BEAM V RECT 836
BEAM V RECT 836
V1
V2
REFL V RECT 5R4WGY
REFL V RECT 5R4WGY
V9
V10
TM 689-397

Figure 126. Power Supply PP–764/G, tube location diagram.


300V
5R4WGY
V1
300V
6AS7G
V2
300V
6AU6
V3
250/150V
5R4WGY
V4
150V
6AS7G
V12
42V
OB2
V14
R9
-150V
6X4W
C4
V15
250/150V
5R4WGY
V5
150V
6AU6
V13
C10
V16
-150V
OA2
150V
6AS7G
C8
R42
250/150V
5R4WGY
V6
V11
250V
6AU6
V9
C7
R26
V7
V8
V10
250V
6AS7G
250V
6AS7G
250/150V
6AS7G

TM689-395

Figure 127. Power Supply PP–689/G, tube location diagram.

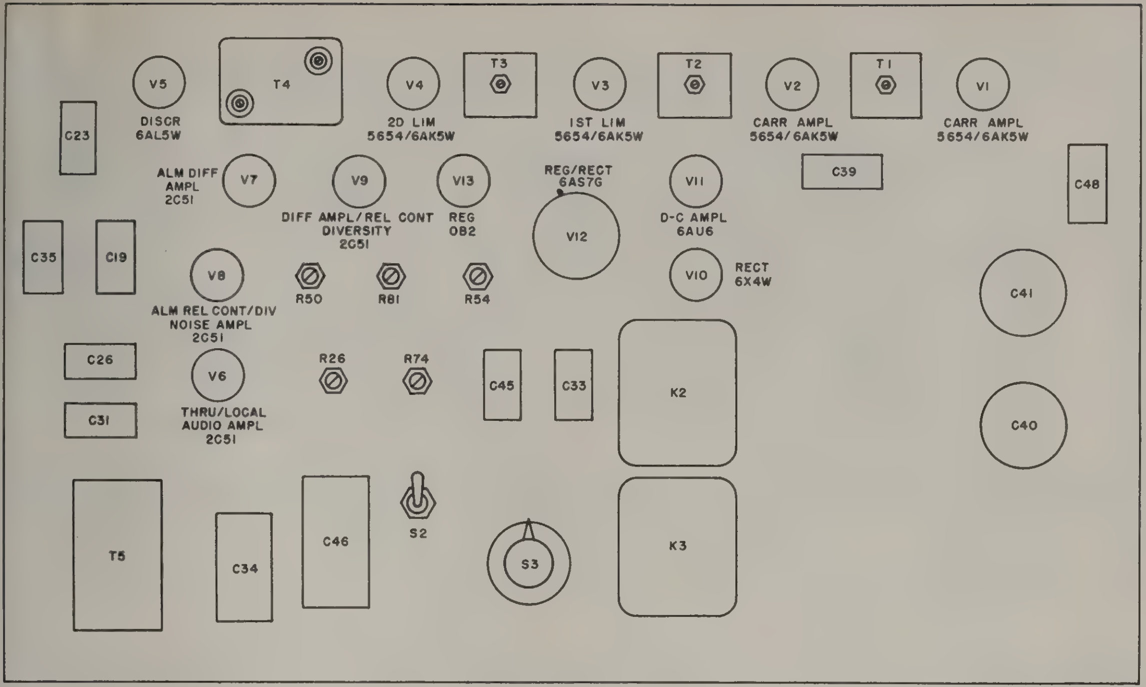

V5
DISCR
6AL5W
T4
V4
2D LIM
5654/6AK5W
T3
V3
IST LIM
5654/6AK5W
T2
V2
CARR AMPL
5654/6AK5W
T1
V1
CARR AMPL
5654/6AK5W
C23
ALM DIFF
AMPL
2C51
V7
V9
DIFF AMPL/REL CONT
DIVERSITY
2C51
V13
REG
0B2
REG/RECT
6AS7G
V12
V11
D-C AMPL
6AU6
C39
C48
C35
C19
V8
ALM REL CONT/DIV
NOISE AMPL
2C51
R50
R81
R54
V10
RECT
6X4W
C41
C26
V6
THRU/LOCAL
AUDIO AMPL
2C51
C31
R26
R74
C45
C33
K2
C40
T5
C34
C46
S2
S3
K3
TM 689-408

Figure 128. Order-wire receiver, tube location diagram.

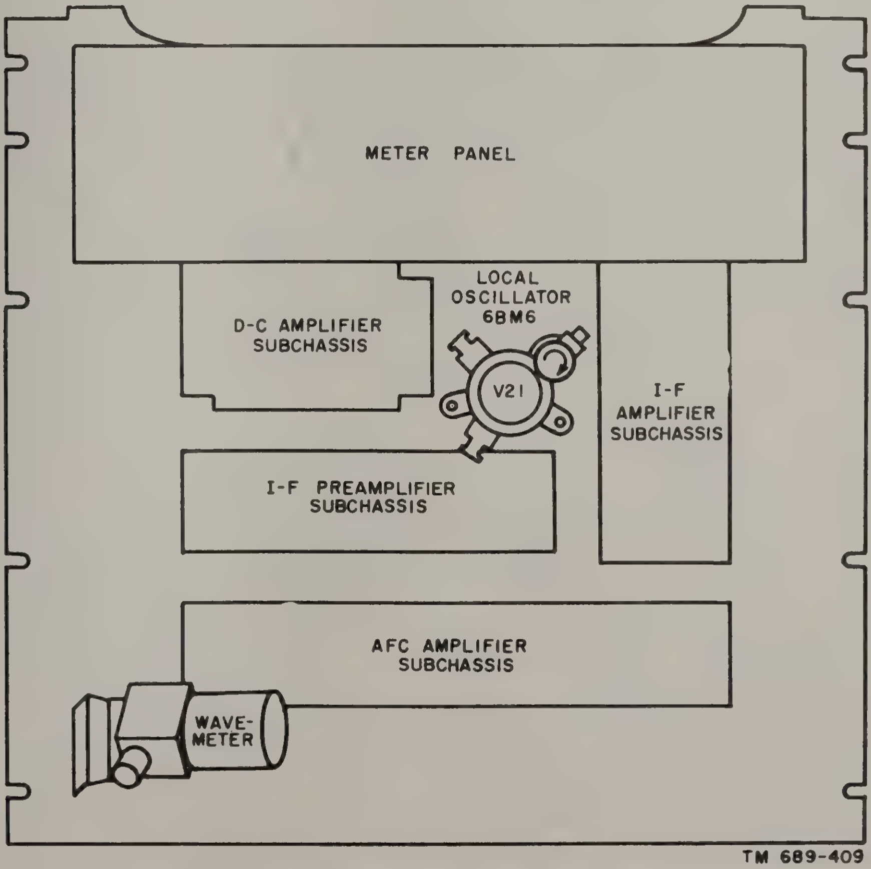

METER PANEL
D-C AMPLIFIER
SUBCHASSIS
LOCAL
OSCILLATOR
6BM6
V21
I-F
AMPLIFIER
SUBCHASSIS
I-F PREAMPLIFIER
SUBCHASSIS
AFC AMPLIFIER
SUBCHASSIS
WAVE-
METER
TM 689-409

Figure 129. Radio receiver main chassis, tube location diagram.

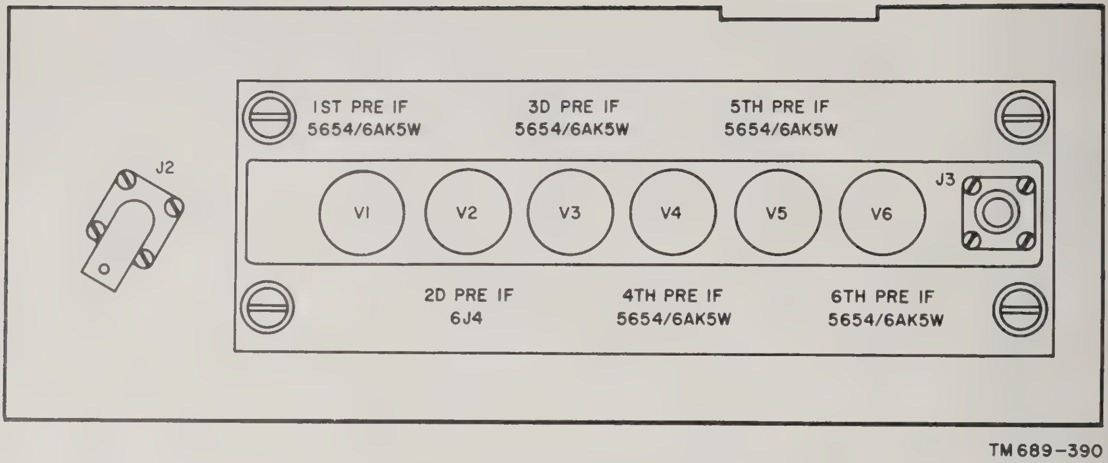

1ST PRE IF
5654/6AK5W
3D PRE IF
5654/6AK5W
5TH PRE IF
5654/6AK5W
J2
J3
V1
V2
V3
V4
V5
V6
2D PRE IF
6J4
4TH PRE IF
5654/6AK5W
6TH PRE IF
5654/6AK5W
TM 689-390

Figure 130. Radio receiver preamplifier, tube location diagram.

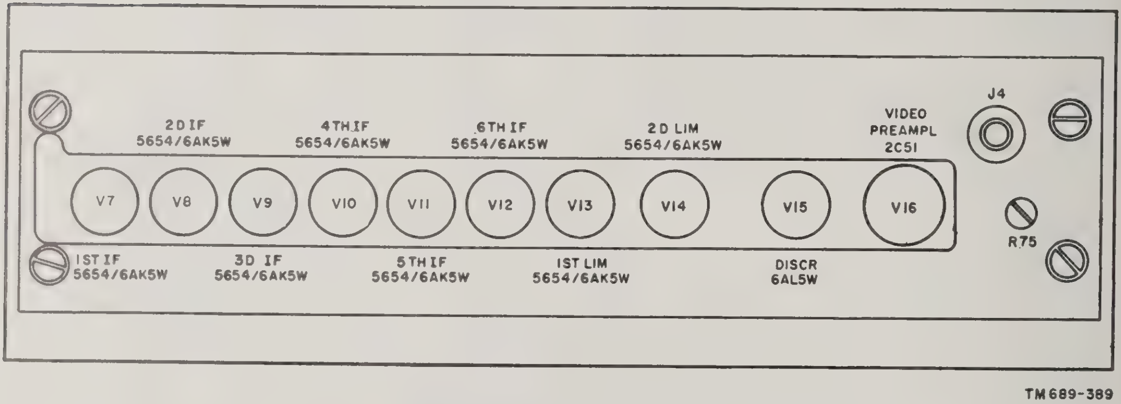

J4
2D IF
5654/6AK5W
4TH IF
5654/6AK5W
6TH IF
5654/6AK5W
2D LIM
5654/6AK5W
VIDEO
PREAMPL
2C51
V7
V8
V9
V10
V11
V12
V13
V14
V15
V16
R75
1ST IF
5654/6AK5W
3D IF
5654/6AK5W
5TH IF
5654/6AK5W
1ST LIM
5654/6AK5W
DISCR
6AL5W
TM 689-389

Figure 131. Radio receiver if. amplifier, tube location diagram.

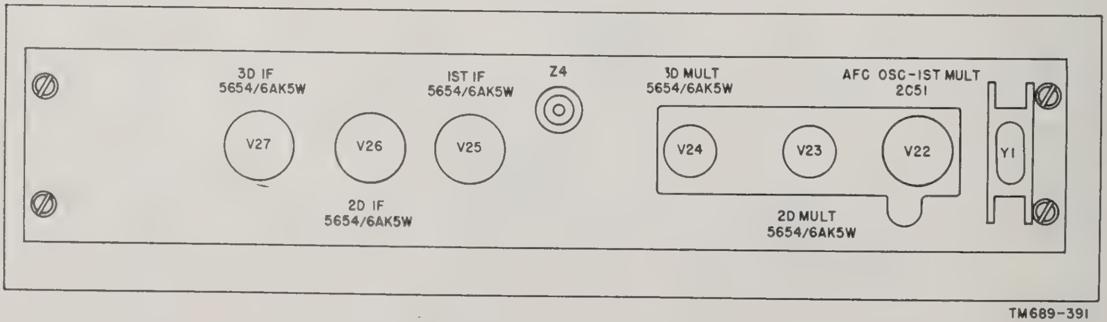
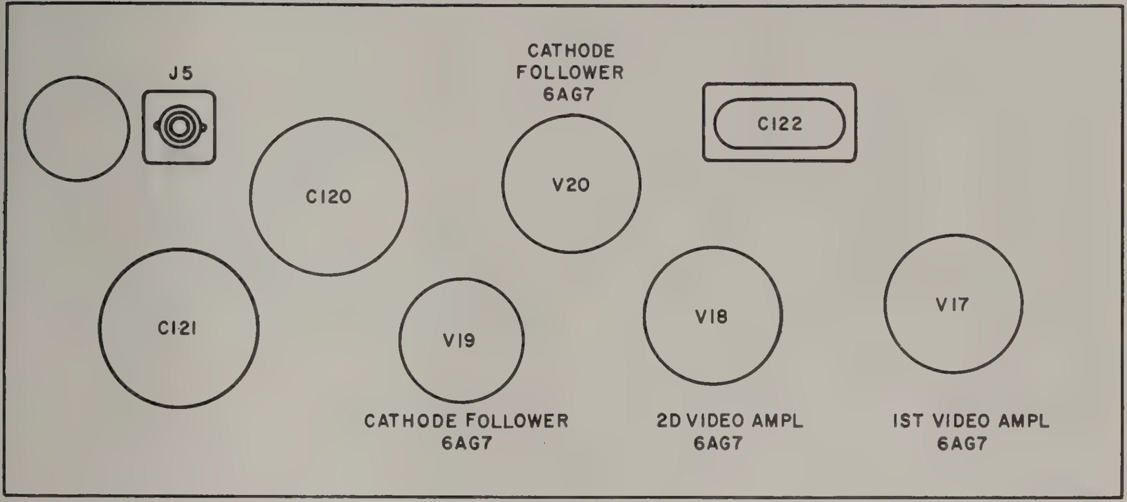
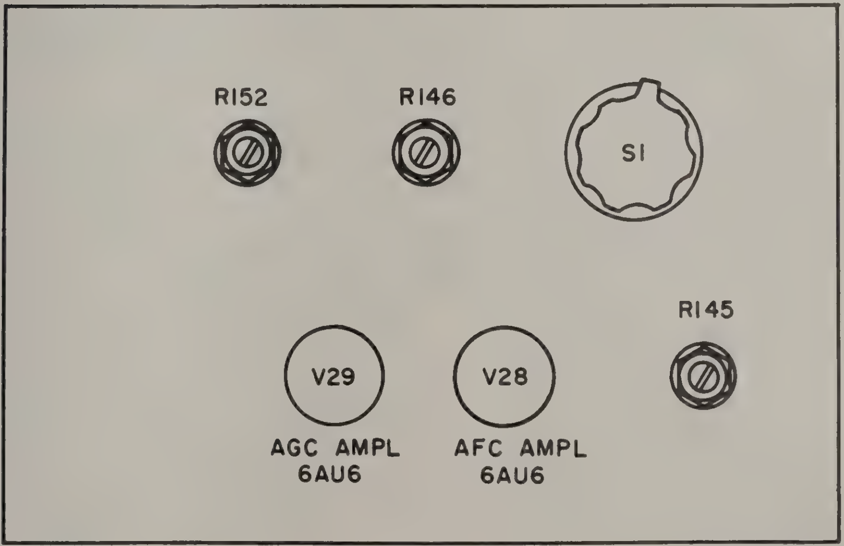

3D IF
5654/6AK5W
1ST IF
5654/6AK5W
Z4
3D MULT
5654/6AK5W
AFC OSC-1ST MULT
2C51
V27
V26
V25
V24
V23
V22
Y1
2D IF
5654/6AK5W
2D MULT
5654/6AK5W
TM689-391

Figure 132. Radio receiver afc, tube location diagram.


J5
CATHODE FOLLOWER 6AG7
C122
C120
V20
C121
V19
V18
V17
CATHODE FOLLOWER 6AG7
2D VIDEO AMPL 6AG7
IST VIDEO AMPL 6AG7

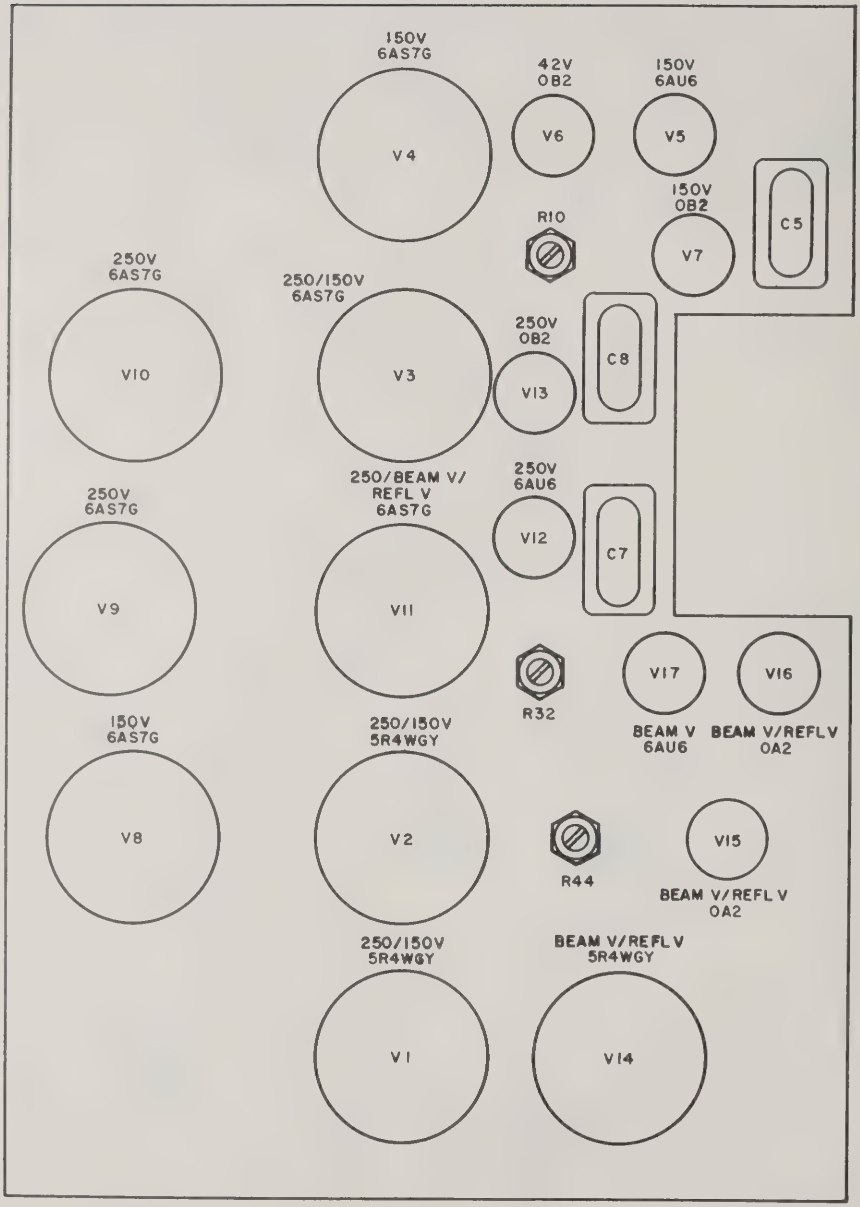
TM 689-393

Figure 133. Radio receiver video amplifier, tube location diagram.


R152
R146
S1
R145
V29
V28
AGC AMPL 6AU6
AFC AMPL 6AU6

TM 689-394

Figure 134. Radio receiver, afc and agc dc amplifier.


150V
6AS7G
V4
42V
OB2
V6
150V
6AU6
V5
150V
OB2
V7
C5
R10
250V
6AS7G
V10
250/150V
6AS7G
V3
250V
OB2
V13
C8
250/BEAM V/
REFL V
6AS7G
V11
250V
6AU6
V12
C7
250V
6AS7G
V9
R32
V17
BEAM V
6AU6
V16
BEAM V/REFL V
OA2
150V
6AS7G
V8
250/150V
5R4WGY
V2
R44
V15
BEAM V/REFL V
OA2
250/150V
5R4WGY
V1
BEAM V/REFL V
5R4WGY
V14

TM689-398

Figure 135. Power Supply PP-690/G, tube location diagram.

133. Special Tube Replacement Procedures

a. General. All tubes in this equipment, except the klystron and power amplifier in the radio transmitter and the klystron in the radio receiver, can be removed by following the standard techniques. The procedures for removing and replacing these tubes are given in *b* through *d* below. Before placing a miniature-type tube in its socket, insert the tube in the 7-pin or 9-pin tube straightener, in the receiver rack.

b. Transmitter Klystron V38. The transmitter klystron is removed and replaced as follows:

(1) Place the INPUT POWER BREAKERS circuit breakers, on back of the high-voltage power supply, in the OFF position.

(2) Turn the large knurled knob of the klystron-motor coupling assembly counterclockwise until the clutch *gives* (usually about 1 turn), and then continue to turn the knob another 2 turns to fully disengage the clutch.

(3) Remove the reflector connecting cap from the klystron.

(4) Remove the transmitter protective back cover by turning the six cam-lock fasteners on the cover about one-half turn counterclockwise. (Disconnect any cables that lead to the back of the transmitter and that prevent removal of the back cover.)

(5) Disconnect the rf cable at the klystron output fitting.

(6) Pull off the octal base connector from the klystron.

(7) Turn the small thumbscrew that holds the grounding strap counterclockwise to loosen the strap and remove it from the klystron output.

(8) Turn the three wing nuts on the klystron mounting posts counterclockwise to free the klystron mount and remove the klystron.

Note. One of the three wingnuts is on an extension shaft.

(9) Examine the new klystron to be sure that the cavity plates are approximately parallel. If necessary, turn the two coarse-tuning screws or the long fine-tuning screw, to make the plates parallel (fig. 92).

(10) Put the klystron into position *without forcing* it. It may be necessary to turn the fine-tuning screw a fraction of a turn, so that it will readily slip into the afc motor coupling.

(11) Fasten the klystron mount securely, by turning the three wingnuts clockwise until they are fingertight. (Refer to note in (8) above.)

(12) Replace the grounding strap. Reconnect the klystron octal base connector.

(13) Replace the rf cable to the klystron output; be sure the connection is fingertight. Tighten the grounding strap by turning the small thumbscrew clockwise.

(14) Replace the back cover and snap the six cam-lock fasteners closed. (Replace any cables that have previously been removed as instructed in (4) above.)

(15) Connect the reflector cap on the klystron.

Caution: Do not re-engage the loosened klystron-motor clutch ((2) above).

(16) Place the INPUT POWER BREAKER circuit breakers in the ON position.

(17) Retune the klystron and the power amplifier as described in paragraph 77.

c. Power Amplifier V37. The power amplifier in the radio transmitter is removed and replaced as follows:

(1) Place the INPUT BREAKER circuit breakers on back of the high-voltage power supply in the OFF position.

(2) Disconnect the power amplifier harness (fig. 136) from the terminal board, behind the HIGH VOLTAGE protective plate.

(3) Disconnect the input and output rf cables from their connectors.

(4) Loosen the three cam-lock fasteners that hold the power amplifier assembly to the chassis. It is now possible to pull the entire power amplifier assembly out.

(5) Unscrew the two knurled screws that hold the safety cover on the assembly, and remove the safety cover. The tube should now be exposed (fig. 137).

(6) Remove the tube.

(7) Insert the new tube carefully in place; be sure that it is centered in the cavity, and that the anode fits in the anode cap. Some pressure may have to be exerted to seat the tube firmly in place. However, it should not be necessary to *force* the tube in place. *Do not exert force.* If the tube does not go in with slight pressure, turn it slightly until it slips in place. When the tube is inserted properly, its retaining ring is flush against the assembly.

(8) Replace the safety cover and screw the knurled screws in place.

(9) Mount the assembly in place on the chassis, and tighten the cam-lock fasteners.

(10) Reconnect the leads that were disconnected in (2) above, to the terminal board.

(11) Place the INPUT POWER BREAKERS in the ON position.

(12) Retune the klystron and power amplifier as described in paragraph 77.

d. Receiver Klystron V21. The receiver klystron is removed and replaced as follows:

(1) Place the INPUT POWER BREAKERS in the OFF position.

(2) Remove the tube base connector.

(3) Turn the retaining ring counterclockwise until it comes off.

(4) Remove the tube.

Caution: Improper insertion of the klystron is possible unless the instructions given in (5) through (10) below are followed.

(5) Put the new klystron in the tube base connector; be sure that the reference pin fits into the proper hole (fig. 138), and slowly swing the tube into the cavity as far as it will go without forcing it. Do not attempt to insert the tube all the way into the cavity. Note the tube position.

Caution: Do not force the klystron into the connector incorrectly. Be sure that the klystron pins have been properly lined up with the connector holes.

(6) Pull the klystron out of the tube base, and gently insert it in the cavity as far as it will go; use the *same position* as that noted in (5) above.

(7) Place the retaining ring in place, and turn it clockwise until it is fingertight.

(8) If the tube is properly positioned, it is possible to replace the tube base connector on the klystron without twisting the connecting cable. Do not *try to force* the connector on the klystron. If it does not go on the tube readily, repeat (5) through (7) above, until it does.

(9) Place the INPUT POWER BREAKER in the ON position.

(10) Retune the klystron to the local-oscillator frequency (par. 83).

134. General Tube Replacement Procedure and Tube Complement

(figs. 118–138)

a. Replacement Practice. Remove and test one tube at a time in the tube tester. Substitute new tubes only for those that are defective. If a tube tester is not available, troubleshoot by the tube substitution method.

(1) Replace the suspected tubes, one at a time, with new tubes. If the equipment becomes operative, discard the last tube removed.

(2) Reinsert the remaining original tubes, one at a time, in the original sockets. If equipment failure occurs during this step, discard the last original tube. *Do not leave a new tube in a socket if the equipment operates satisfactorily with the original tube.*

(3) As a general rule, discard tubes only when a tube tester shows that the tube is defective, or when the tube defect is obvious, such as a broken prong or broken glass envelope.

(4) Do not discard tubes merely because the tubes have been used for a specified length of time. Satisfactory operation in a circuit is the final proof of tube quality. The tube in use may work better than a new one.

(5) Be very careful when withdrawing a miniature tube from its socket. Do not rock or rotate the top of a miniature tube when removing it—pull the

tube straight out. The external pin and the wire lead sealed in the glass base are of two different metals which are butt-welded together where the pin appears to enter the glass. Rocking or rotating causes bending, which tends to break this weld or cause a resistance or intermittent joint to develop.

b. Tube Complement. The charts below identify all tubes that are used in the radio set.

(1) *Order Wire Transmitter T–389/TRC–29.*

Symbol	Tube type	Function
V1	2C51	Audio amplifier.
V2	5725/6AS6W	Carrier oscillator.
V3	5654/6AK5W	Carrier limiter.
V4	5725/6AS6W	Carrier amplifier.
V5	5654/6AK5W	Test tone oscillator.
V6	2C51	Afc amplifier.
V7	5725/6AL5W	Afc discriminator.
V8	5654/6AK5W	Afc limiter.
V9	6X4W	Rectifier.
V10	6AS7G	Rectifier regulator.
V11	OB2	Voltage regulator.
V12	6AU6	Dc amplifier.

(2) *Radio Transmitter T–303/G.*

Symbol	Tube type	Function
V1	2C51	First video amplifier.
V2	2C51	Second video amplifier.
V3	6AG7	Third video amplifier.
V4	6AG7	Fourth video amplifier.
V5	6AG7	Fourth video amplifier.
V6	829B	Fifth video amplifier.
V7	6X4W	Reflector protective diode.
V8	807	Regulator.
V9	6AU6	Dc amplifier.
V10	OB2	Voltage reference.
V11	2C51	Afc oscillator—first multiplier.
V12	5654/6AK5W	Afc tripler.
V13	5654/6AK5W	First if. amplifier.
V14	5654/6AK5W	Second if. amplifier.
V15	5654/6AK5W	Third if. amplifier.
V16	5654/6AK5W	Fourth if. amplifier.
V17	5654/6AK5W	Fifth if. amplifier.
V18	5654/6AK5W	Sixth if. amplifier.
V19	5654/6AK5W	First limiter.
V20	5654/6AK5W	Second limiter.
V21	5726/6AL5W	Discriminator.
V22	2C51	Video preamplifier.
V23	2C51	Chopper amplifier.
V24	2C51	Chopper amplifier—phase inverter.
V25	5726/6AL5W	Peak detector.
V26	2C51	Relay controls.
V27	2C51	Sawtooth oscillator.
V28	6AG7	First vtvm video amplifier.
V29	6AG7	Second vtvm video amplifier.
V30	6AG7	Third vtvm video amplifier.
V31	5726/6AL5W	Vtvm detector.
V32	2C51	Vtvm dc amplifier.
V33	6AG7	Monitor amplifier.
V34	5654/6AK5W	Monitor order-wire amplifier.
V35	5726/6AL5W	Monitor order-wire detector.
V36	2C51	Relay control.
V37	2C39A	Power amplifier.
V38	SRL7–F or SRL7–G or SRL7–H depending on frequency of operation.	Klystron oscillator.

(3) *Power Supply PP–764/G.*

Symbol	Tube type	Function
V1	836	Rectifier.
V2	836	Rectifier.
V3	807	Regulator.
V4	807	Regulator.
V5	807	Regulator.
V6	807	Regulator.
V7	6AU6	Dc amplifier.
V8	OA2	Voltage regulator.
V9	5RYWGA	Rectifier.
V10	5RYWGA	Rectifier.
V11	5RYWGA	Rectifier.

(4) *Order Wire Receiver R–543/TRC–29.*

Symbol	Tube type	Function
V1	5654/6AK5W	First carrier amplifier.
V2	5654/6AK5W	Second carrier amplifier.
V3	5654/6AK5W	First limiter.
V4	5654/6AK5W	Second limiter.
V5	5726/6AL5W	Discriminator.
V6	2C51	Audio amplifier.
V7	2C51	Alarm differential amplifier.

(4) *Order Wire Receiver R–543/TRC–29*—cont'd.

Symbol	Tube type	Function
V8	2C51	Alarm relay control—diversity noise amplifier.
V9	2C51	Diversity differential amplifier relay control.
V10	6X4W	Rectifier.
V11	6AU6	Dc amplifier.
V12	6AS7G	Regulator-rectifier.
V13	OB2	Voltage regulator.

(5) *Radio Receiver R–418/G.*

Symbol	Tube type	Function
V1	5654/6AK5W	First if. amplifier.
V2	6J4	Second if. amplifier.
V3	5654/6AK5W	Third if. amplifier.
V4	5654/6AK5W	Fourth if. amplifier.
V5	5654/6AK5W	Fifth if. amplifier.
V6	5654/6AK5W	Sixth if. amplifier.
V7	5654/6AK5W	Seventh if. amplifier.
V8	5654/6AK5W	Eighth if. amplifier.
V9	5654/6AK5W	Ninth if. amplifier.
V10	5654/6AK5W	Tenth if. amplifier.
V11	5654/6AK5W	Eleventh if. amplifier.
V12	5654/6AK5W	Twelfth if. amplifier.
V13	5654/6AK5W	First limiter.
V14	5654/6AK5W	Second limiter.
V15	5726/6AL5W	Discriminator.
V16	2C51	Video preamplifier.
V17	6AG7	First video amplifier.
V18	6AG7	Second video amplifier.
V19	6AG7	Cathode follower.
V20	6AG7	Cathode follower.
V21	6BM6	Local oscillator.
V22	2C51	Afc oscillator—first multiplier.
V23	5654/6AK5W	Afc second multiplier.
V24	5654/6AK5W	Afc third multiplier.
V25	5654/6AK5W	Afc first if. amplifier.
V26	5654/6AK5W	Afc second if. amplifier.
V27	5654/6AK5W	Afc third if. amplifier.
V28	6AU6	Agc dc amplifier.
V29	6AU6	Afc dc. amplifier.

(6) *Power Supply PP–690/G.*

Symbol	Tube type	Function
V1	5RYWGA	Rectifier.
V2	5RYWGA	Rectifier.
V3	6AS7G	Regulator.
V4	6AS7G	Regulator.
V5	6AU6	Dc amplifier.
V6	OB2	Voltage regulator.
V7	OB2	Voltage reference.
V8	6AS7G	Regulator.
V9	6AS7G	Regulator.
V10	6AS7G	Regulator.
V11	6AS7G	Regulator.
V12	6AU6	Dc amplifier.
V13	OB2	Voltage reference.
V14	5RYWGA	Rectifier.
V15	OA2	Voltage regulator—reference.
V16	OA2	Voltage regulator—reference.
V17	6AU6	Dc amplifier.

(7) *Power Supply PP–689/G.*

Symbol	Tube type	Function
V1	5RYWGA	Rectifier.
V2	6AS7G	Regulator.
V3	6AU6	Dc amplifier.
V4	5RYWGA	Rectifier.
V5	5RYWGA	Rectifier.
V6	5RYWGA	Rectifier.
V7	6AS7G	Regulator.
V8	6AS7G	Regulator.
V9	6AU6	Dc amplifier.
V10	6AS7G	Regulator.
V11	6AS7G	Regulator.
V12	6AS7G	Regulator.
V13	6AU6	Dc amplifier.
V14	OB2	Voltage regulator.
V15	6X4W	Rectifier.
V16	OA2	Voltage regulator—reference.

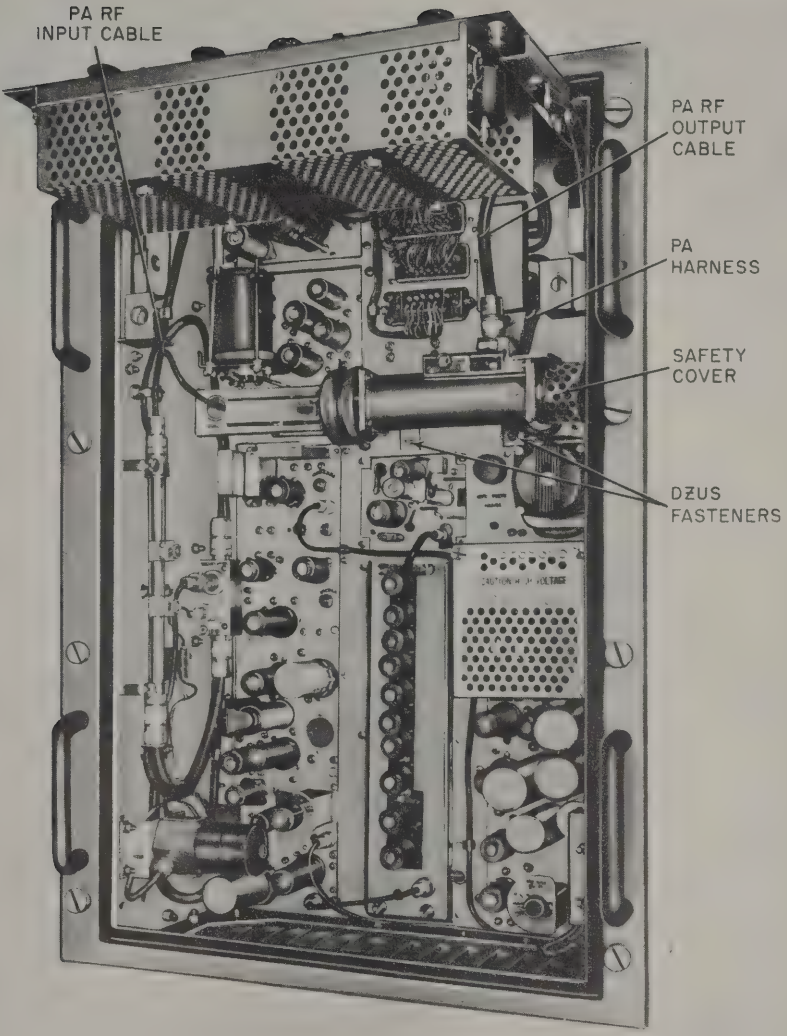

PA RF INPUT CABLE
PA RF OUTPUT CABLE
PA HARNESS
SAFETY COVER
DZUS FASTENERS
CAUTION HIGH VOLTAGE
TM689-311

Figure 136. Radio transmitter, front view with power amplifier connection.

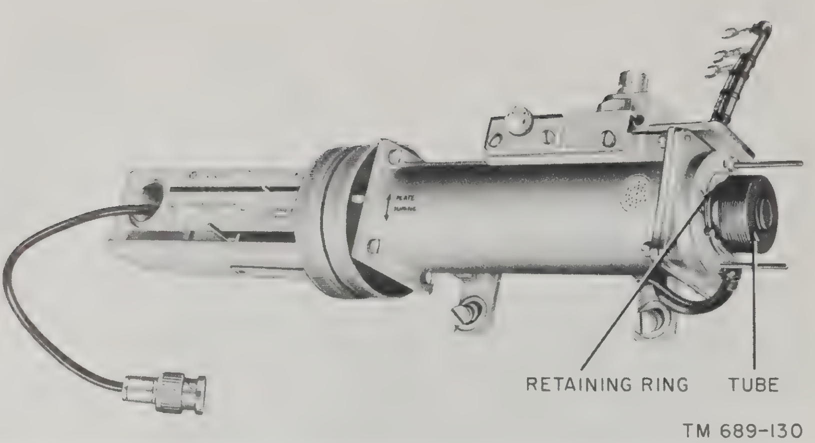

RETAINING RING
TUBE
TM 689-130

Figure 137. Power amplifier assembly.

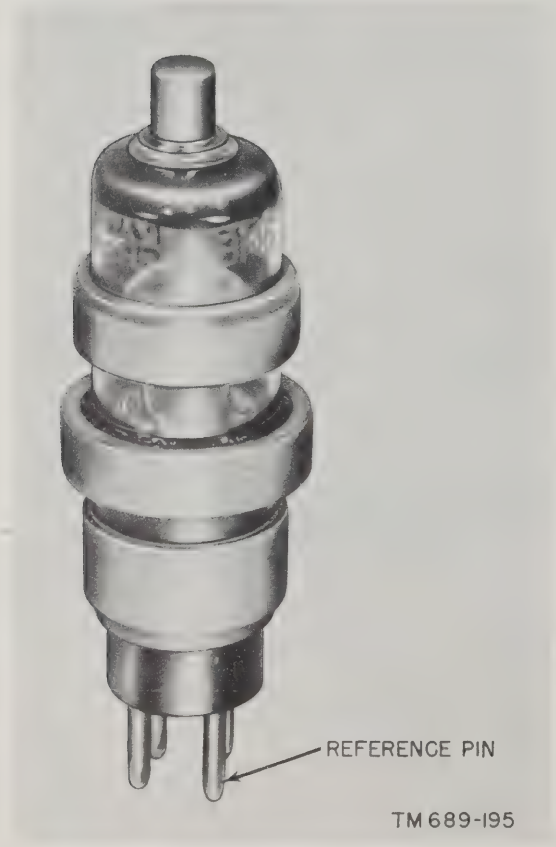

REFERENCE PIN
TM 689-195

Figure 138. Receiver klystron.

135. Interchangeable Tubes

The older type tube listed in the first column in the chart below can be replaced with the corresponding preferred type tube listed in the third column. The second column lists the stage or stages in which the tubes can be used in Radio Set AN/TRC-29. The older type tube may be used until stocks are exhausted.

Caution: Never replace tube 2C51 with another tube type.

Older tube type	Application	Preferred tube
6AG7	V3, third video amplifier, Radio Transmitter T-303/G.	6AG7Y
	V4, fourth video amplifier, Radio Transmitter T-303/G.	
	V5, fourth video amplifier, Radio Transmitter T-303/G.	
	V28, first vtvm video amplifier, Radio Transmitter T-303/G.	
	V29, second vtvm amplifier, Radio Transmitter T-303/G.	
	V30, third vtvm amplifier, Radio Transmitter T-303/G.	
	V33, monitor amplifier, Radio Transmitter T-303/G.	
	V17, first video amplifier, Radio Receiver R-418/G.	
	V18, second video amplifier, Radio Receiver R-418/G.	
	V19, cathode follower, Radio Receiver R-418/G.	
	V20, cathode follower, Radio Receiver R-418/G.	
6AU6	V12, dc amplifier, Order Wire Transmitter T-389/TRC-29.	6AU6WA
	V9, dc amplifier, Radio Transmitter T-303/G.	
	V7, dc amplifier, Power Supply PP-7641/G.	
	V11, dc amplifier, Order Wire Receiver R-543/TRC-29.	
	V28, agc dc amplifier, Radio Receiver R-418/G.	
	V29, agc dc amplifier, Radio Receiver R-418/G.	
	V5, dc amplifier, Power Supply PP-690/G.	
	V12, dc amplifier, Power Supply PP-690/G.	
	V17, dc amplifier, Power Supply PP-690/G.	
	V3, dc amplifier, Power Supply PP-689/G.	
	V9, dc amplifier, Power Supply PP-689/G.	
	V13, dc amplifier, Power Supply PP-689/G.	
807*	V8, regulator, Radio Transmitter T-303/G.	5933
	V3, regulator, Power Supply PP-764/G.	
	V4, regulator, Power Supply PP-764/G.	
	V5, regulator, Power Supply PP-764/G.	
	V6, regulator, Power Supply PP-764/G.	
5R4WGY	V9, rectifier, Power Supply PP-764/G.	5R4WGA
	V10, rectifier, Power Supply PP-764/G.	
	V11, rectifier, Power Supply PP-764/G.	
	V1, rectifier, Power Supply PP-690/G.	
	V2, rectifier, Power Supply PP-690/G.	
	V14, rectifier, Power Supply PP-690/G.	
	V1, rectifier, Power Supply PP-689/G.	
	V4, rectifier, Power Supply PP-689/G.	
	V5, rectifier, Power Supply PP-689/G.	
	V6, rectifier, Power Supply PP-689/G.	
6AL5W	V7, afc discriminator, Order Wire Transmitter T-389/TRC-29.	5726/6AL5W
	V21, discriminator, Radio Transmitter T-303/G.	
	V25, peak detector, Radio Transmitter T-303/G.	
	V31, vtvm detector, Radio Transmitter T-303/G.	
	V35, monitor order-wire detector, Radio Transmitter T-303/G.	
	V5, discriminator, Order Wire Receiver R-543/TRC-29.	
	V15, discriminator, Radio Receiver R-418/G.	

*The 807 and 5933 use different electron tube retainers.

CHAPTER 5

AUXILIARY AND ALTERNATE EQUIPMENT

Section I. AUXILIARY EQUIPMENT

136. Power Unit PE–95 for Emergency Power

a. General. Radio Set AN/TRC–29 normally is operated from commercial power lines that deliver a nominal voltage of either 100 to 130 or 200 to 260 volts ac, at 50 to 60 cps. When a commercial line cannot be connected to the station, or any emergency source of power is desired, PE–95 can be used.

b. Description of Power Unit PE–95. Power Unit PE–95 is a nominal 10-kw, 120-volt, 60-cycle, single-phase, gasoline-engine-driven generator capable of supplying 7 kw at altitudes up to 10,000 feet. For details, refer to TM 11–904. Power Unit PU–248/U, which is trailer mounted and consists of one Power Unit PE–95 mounted in a 1½-ton Ordnance Cargo Trailer XM–105, may be used if available.

c. Connection to Radio Set AN/TRC–29. The gasoline-generator output cable is connected to the INPUT 1 jack on Switch Box SA–357/G by cable CX–2442/U (10 ft). The switch on this box is placed in position 1 when the PE–95 output is to be used as a primary power source.

137. Tower Lighting

a. When towers are installed near a landing strip, an air lane, or an air navigational aid, visual obstruction markings must be provided on the tower. For night recognition, a beacon and warning lights are mounted on the tower. For daylight marking, the tower is painted in alternate *strips* of orange and white. Refer to the Civil Aeronautics Administration Manual, Obstruction Marking, 1 February 1951.

Note. In the Continental United States, it is mandatory that the CAA be notified prior to the erection or modification of towers. Use Form ACA–117 (which may be obtained from the nearest CAA Regional Office) to submit this information to the nearest CAA Regional Office. Refer also to TM 11–5073 for additional striping and marking details, and description of mounting hardware for lights.

b. The necessary lights must be obtained commercially, because they are not a part of the AB–216/U towers and have not been obtained for depot issue. The uppermost beacon may be Light, Obstruction, 300-mm. elec. code, Beacon type FCB–12, Crouse-Hinds, or equal; with Lamp, incandescent, 500-watt, PS–40 traffic signal; and Flasher, Westinghouse code flasher style #1567745, 110-volt, 60-cycle, 40 rpm, or equal. This side light may be Lamp, incandescent, 100-watt, A–21/TS/115, clear traffic signal, GE No. 100, or equal; in Light, obstruction, No. 44527, Crouse-Hinds, or equal. These lights must be wired with power wiring, protection breakers (35 amperes) in accordance with standard approved procedures by electricians serving the area.

138. Shelter

The radio equipment should be operated in semipermanent buildings. For short term operation, shelter, tent, wall; Large 14 feet 6 inches by 14 feet 6 inches, stock No. 24–T–323–750 or tent, frame type, insulated, sectional floor, 16 feet by 16 feet built to Military specification MIL–T–10168A (QMC), will give adequate protection.

Section II. ALTERNATE EQUIPMENT

139. General

Radio Set AN/TRC–29 is designed to be used with Multiplexer Set AN/TCC–13, Multiplexer Group AN/TCA–1, and Pulse Form Restorer Group AN/TRA–10, but it may also be used with other communication systems (par. 7). Some of the equipment used in these other systems is described below.

140. Multiplexer Set AN/TCC–15

a. General. Multiplexer Set AN/TCC–15 and Pulse Form Restorer Group AN/TRA–18 use a system of modulation known as pulse-code modulation for transmission of 48 audio channels over the Radio Set AN/TRC–29 relay system.

b. Terminal Connections. At a terminal using Multiplexer Set AN/TCC–15, make connections to the radio set as follows:

(1) Connect the video cable between the video out receptacle of the AN/TCC–15 and the VIDEO FILTER INPUT receptacle on the back of the radio transmitter. Connect the cable from the VIDEO FILTER OUTPUT receptacle to the VIDEO INPUT receptacle to the VIDEO INPUT receptacle.

(2) Connect the video cable from the video in receptacle of the AN/TCC–15 to the VIDEO OUT receptacle of the order-wire receiver.

c. Repeater Station Connections. At the repeater station that requires any AN/TRA–18 equipment, make the following connections:

(1) Connect the video cable between the video out receptacle of the (east-west) AN/TRA–18 and the VIDEO IN receptacle of the AN/TRC–29 (east-west radio transmitter).

(2) Connect the video cable between the video out receptacle of the (west-east) AN/TRA–18 and the VIDEO IN receptacle of the AN/TRC–29 (west-east radio transmitter).

(3) Connect the video cable between the video in jack of the (east-west) AN/TRA–18 and the VIDEO OUT jack of the (east-west) radio receiver.

(4) Connect the video cable between the video in jack of the (west-east) AN/TRA–18 to the VIDEO OUT jack of the (west-east) radio receiver.

141. Subcarrier Group AN/TSA–10

a. General. Subcarrier Group AN/TSA–10 provides a maximum of 36 audio channels when used with suitable frequency-division-multiplexing equipment. The frequency-multiplex spectrum of signals modulates a 1-mc subcarrier in the AN/TSA–10 equipment, and the modulated subcarrier signal is fed to the radio set. At the receiver end, the 1-mc modulated signal is fed to a subcarrier demodulator in the AN/TSA–10, which recovers the multiplex signal. The multiplex signal then is fed to the frequency-division equipment, where it is separated and demodulated to individual audio signals. Subcarrier Group AN/TSA–10 is housed in a single 5-foot rack (Electrical Standardized Components Case CY–1280/U). Subcarrier Group AN/TSA–10 integrates directly into the AN/TCC–7 systems to provide a 12-channel system.

b. Connections. The frequency-division-multiplex set is connected to the radio set as follows:

(1) Connect the video cable between the video out receptacle of the AN/TSA–10 to the VIDEO FILTER INPUT receptacle of the radio transmitter. Connect the cable between the VIDEO FILTER OUTPUT and the VIDEO INPUT receptacles.

(2) Connect the video cable from the video in receptacle of the AN/TSA–10 to the VIDEO OUT receptacle of the order-wire receiver.

142. Commercial Television Link

a. General. Radio Set AN/TRC–29 can be used to transmit television signals within the bandwidth of 30 cycles to 4.5 mc. Any commercial television pickup equipment (providing 1 to 2 peak-to-peak volts into 50 ohms) can be used to generate the television signal, and the video output (1 volt into 50 ohms) of the radio set can be fed into a commercial transmitter console. At every third repeater site a stabilizing amplifier, such as the Dumont Type 5270–C, must be used to expand the synchronizing pulse, to clamp the signal, and to improve the low-frequency response. The stabilizing amplifier is mounted in a 19-inch rack, includes a self-contained power supply, which operates on 115 volts ac, and requires 185 watts. Because the input and output impedances of commercial television equipment are 72 ohms, a 72- to 50-ohm impedance-matching network must be placed between the television equipment output and the radio set video input. Similarly, a 50- to 72-ohm impedance-matching network is required between the AN/TRC–29 video output and the television equipment input.

b. Connections to Pickup Terminal. Connection is made between the pickup equipment and the AN/TRC–29 transmitter by connecting a video cable and a 72- to 50-ohm impedance-matching network between the pickup output and the VIDEO FILTER INPUT receptacle of the radio transmitter. Connect the cable between the VIDEO FILTER OUTPUT and the VIDEO INPUT receptacles.

c. Connection to Transmitter Terminal. Connection is made between the VIDEO OUT jack of the order-wire receiver to the transmitter console video input jack through a 50- to 72-ohm impedance-matching network.

d. Connections to Repeater Station.

(1) Connect the VIDEO OUT receptacle of (east-west) order-wire receiver to the video input connection of the stabilizing amplifier through a 50- to 72-ohm impedance-matching network.

(2) Connect the VIDEO INPUT receptacle of the (east-west) radio transmitter to the video output of the stabilizing amplifier, through a 72- to 72-ohm impedance-matching network. (Connect the cable between the VIDEO FILTER OUTPUT and the VIDEO FILTER INPUT receptacles.)

(3) Connect the primary power cable of the stabilizing amplifier to the extra jack on Switchbox SA–357/G.

(4) Perform the steps in (1) and (2) above for west-east equipment.

143. Multiplex Equipments OA–504/FRC and OA–502/FRC of Navy Model UQ Radio Relay Link

a. Any suitable multiplex equipment that provides an output within the frequency range of 30 cycles to 4.5 mc can be used with the radio set. However, the output and input signals of such equipment must match the requirements of the radio set; that is, a video input signal of 1 to 2 volts into 50 ohms and a video output signal of .5 volt into 50 ohms. If these requirements are not met, suitable matching networks are required.

b. Multiplex Equipments OA–504/FRC and OA–502/FRC of Navy model UQ Radio Relay Link provide a 23-channel ppm video output within the bandwidth requirements of the radio set. However, this equipment provides a video output of 12 volts into 70 ohms and a video input signal of 5 volts into 70 ohms.

c. To use this multiplex equipment, the following special matching equipments are required:

(1) A 10-to-1 attenuator and a 70- to 50-ohm impedance-matching network, which are connected between the output of OA–504/FRC and the VIDEO FILTER INPUT receptacle of the radio transmitter.

(2) A video amplifier capable of accepting a .5-volt signal into an input impedance of 50 ohms and delivering a 5-volt output signal into 70 ohms. This video amplifier is connected between the VIDEO OUT receptacle of the order-wire receiver and the video input of the OA–502/FRC.

144. Radio Set AN/FRC–23 and Radio Repeater Set AN/FRC–26

Radio Set AN/FRC–23 and Radio Repeater Set AN/FRC–26 will work with Radio Set AN/TRC–29 or Multiplexer Set AN/TCC–13. The interconnecting level is 1 volt into 50 ohms and is satisfactory.

Note. Without a filter, the AN/TCC–13 does not provide a dc return for the output cathode follower of the receiver. A 68-ohm, ½-watt resistor must be added between the center conductor of J1 on AN/TCC–13 and ground.

CHAPTER 6

THEORY OF OPERATION

Section I. INTRODUCTION

145. General

a. Radio Set AN/TRC–29 is a transmitter-receiver for radio communication. With certain accessory equipment, it is used as a link in a microwave radio relay system. The system employs frequency modulation of the carrier wave in the frequency range of 1,700 to 2,400 mc. The equipment is capable of transmitting and receiving main-channel video signals in a band from 30 cps to 4.5 mc. These video signals may consist of 45 multiplexed voice channels or less, or one television channel. In addition an order-wire channel permits voice communication on a party line basis among all the stations in the system, primarily for maintenance purposes.

b. Radio Set AN/TRC–29, with its accessory equipment, may be separated into four major groups—transmitting equipment, receiving equipment, antenna equipment, and accessory equipment. The units in the transmitting equipment group are discussed in paragraph 148; those in the receiving equipment group are discussed in paragraph 149; those in the antenna equipment group are discussed in paragraph 150; and those in the accessories are discussed in paragraph 151.

c. The radio set has several useful and convenient auxiliary facilities and features. The order-wire signaling and ringing facilities are described briefly in paragraph 152, the alarm facilities in paragraph 153, some data on the power distribution arrangements is given in paragraph 154, and information on the built-in test and monitoring circuits is given in paragraph 155.

d. The major AN/TRC–29 groups may be used at a terminal station or at a repeater station. When unfavorable reception conditions require it, two receiving equipments may be connected for diversity operation. The equipment arrangement at a typical terminal station is discussed in paragraph 156. Repeater operation is covered in paragraph 157, and diversity operation in paragraph 158. The detailed discussion of the equipment in later sections of this chapter covers the theory of operation of one Radio Set AN/TRC–29 but, since it is the one most commonly encountered, operation in a repeater station is assumed. For the same reason, a repeater station is assumed in discussions concerning diversity operation.

146. Facilities of Radio Set AN/TRC–29

a. General. Radio Set AN/TRC–29 is the basic equipment in a radio relay system. It contains all the components necessary to furnish 2-way transmission and reception of a microwave carrier operating in the frequency range of 1,700 mc to 2,400 mc and frequency modulated by external video signals in the band of 30 cps to 4.5 mc. This equipment uses Duplexers CU–368/TRC and CU–369/TRC–29, which permit the use of one antenna system for both transmission and reception. An order-wire circuit is provided for use during the maintenance of the radio relay circuits, which performs the following functions:

(1) Permits voice communication on a party line basis and ring-through between all stations.

(2) Provides an automatic station alarm.

b. Grouping of Components. The components of Radio Set AN/TRC–29 may be divided into four functional equipments. The grouping of components of the set (fig. 139) is as follows:

(1) *Transmitting equipment.* This equipment consists of Radio Transmitter T–303/G, Order-Wire Transmitter T–389/TRC–29, Power Supply PP–764/G, and Power Supply PP–689/G.

(2) *Receiving equipment.* This equipment consists of Radio Receiver R–418/G, Order-Wire Receiver R–543/TRC–29, Power Supply PP–690/G, and Handset-Signaling Unit H–102/TRC–29.

(3) *Antenna equipment.* This equipment consists of Antenna AS–554/TRC–29, Duplexer CU–368/TRC–29, or Duplexer CU–369/TRC–29, and Radio Frequency Transmission Line Assembly CG–1013/U.

(4) *Primary power input equipment.* This equipment consists of Switchbox SA–357/G and Fixed Autotransformer Power Tranformer TF–146/G.

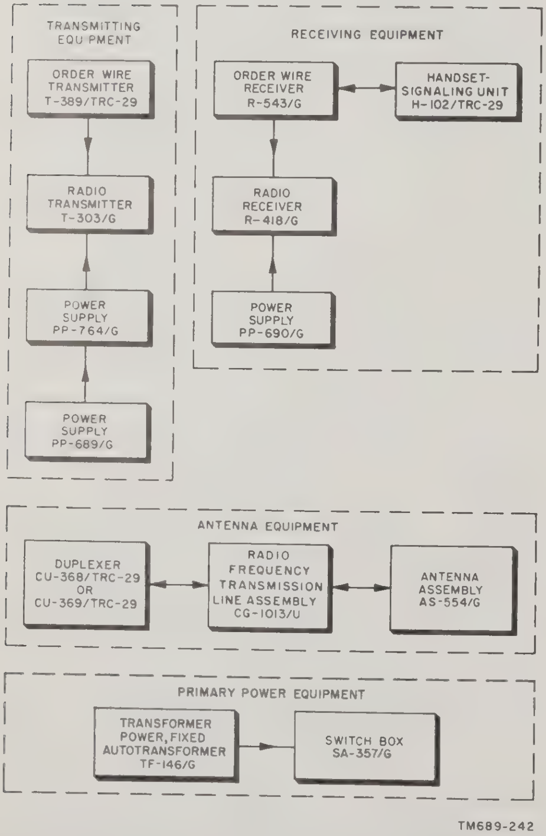

TRANSMITTING EQUIPMENT
ORDER WIRE TRANSMITTER T-389/TRC-29
RADIO TRANSMITTER T-303/G
POWER SUPPLY PP-764/G
POWER SUPPLY PP-689/G
RECEIVING EQUIPMENT
ORDER WIRE RECEIVER R-543/G
HANDSET-SIGNALING UNIT H-102/TRC-29
RADIO RECEIVER R-418/G
POWER SUPPLY PP-690/G
ANTENNA EQUIPMENT
DUPLEXER CU-368/TRC-29 OR CU-369/TRC-29
RADIO FREQUENCY TRANSMISSION LINE ASSEMBLY CG-1013/U
ANTENNA ASSEMBLY AS-554/G
PRIMARY POWER EQUIPMENT
TRANSFORMER POWER, FIXED AUTOTRANSFORMER TF-146/G
SWITCH BOX SA-357/G
TM689-242

Figure 139. Radio Set AN/TRC–29, functional diagram showing relation of equipment.

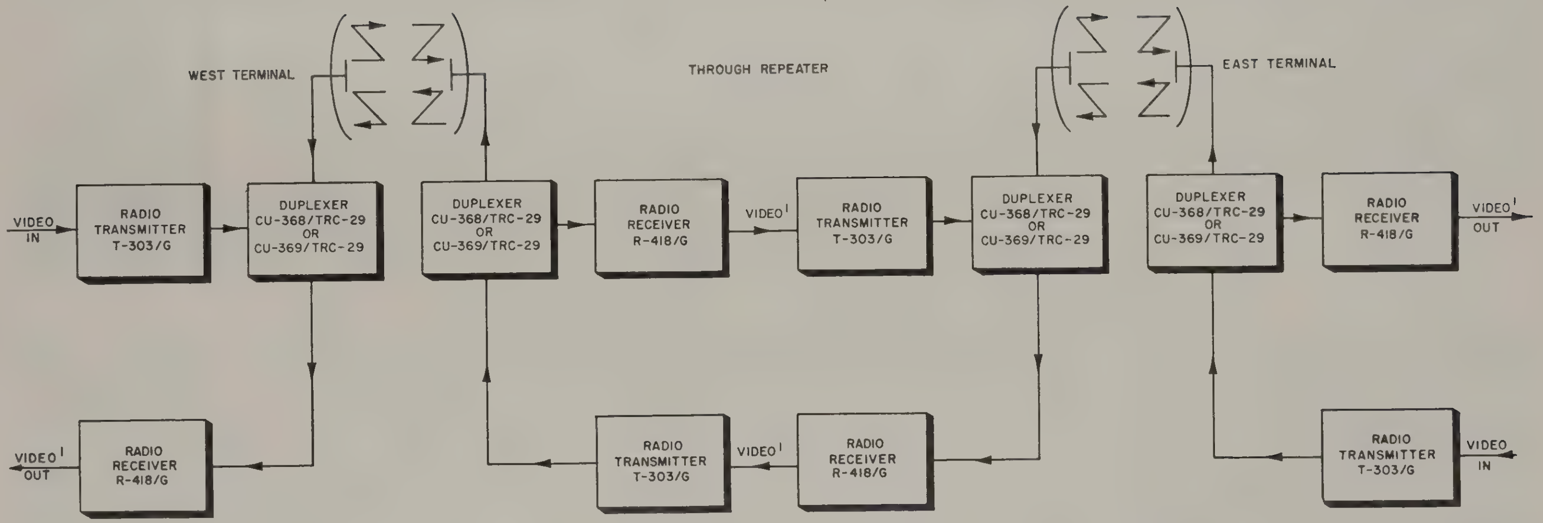
147. Overall Operation of Radio Set AN/TRC–29

a. General. Two types of signals are transmitted over Radio Set AN/TRC–29. One is the main video signal, the other is the order-wire signal. To simplify discussion, the main signal and order-wire signal paths are described in *b* and *c* below. However, the order-wire signal is combined with the main signal at the input to the radio transmitter, follows the main signal path up to the output of the radio receiver, and is separated then from the video signal.

b. Main Signal Path. Figure 140 shows a simplified block diagram of the main signal path in a basic radio relay system employing Radio Set AN/TRC–29.

(1) At the west terminal, the video input signals are fed to the radio transmitter, where they are used to frequency modulate the microwave carrier output of the transmitter. The transmitter output is fed to the duplexer portion of the antenna system common to both transmission and reception. The duplexer prevents the transmitter output from entering the radio receiver and directs it through the surface-wave transmission line to the common parabolic antenna.

(2) The antenna beams the modulated microwave carrier to the antenna at the repeater station, where the signals are fed through duplexer, which prevents them from entering the radio transmitter and directs them to the radio receiver. The receiver amplifies and detects the modulated microwave carrier to produce a video output. This video output is fed to the radio transmitter, where it is used to frequency modulate the carrier produced by the transmitter. The new, modulated microwave carrier then is fed through the duplexer and surface-wave transmission line to the antenna, which transmits the modulated carrier to the antenna at the east terminal. Here the signal is fed through the duplexer to


WEST TERMINAL
THROUGH REPEATER
EAST TERMINAL
VIDEO IN
RADIO TRANSMITTER T-303/G
DUPLEXER CU-368/TRC-29 OR CU-369/TRC-29
DUPLEXER CU-368/TRC-29 OR CU-369/TRC-29
RADIO RECEIVER R-418/G
VIDEO1
RADIO TRANSMITTER T-303/G
DUPLEXER CU-368/TRC-29 OR CU-369/TRC-29
DUPLEXER CU-368/TRC-29 OR CU-369/TRC-29
RADIO RECEIVER R-418/G
VIDEO1 OUT
VIDEO1 OUT
RADIO RECEIVER R-418/G
RADIO TRANSMITTER T-303/G
VIDEO1
RADIO RECEIVER R-418/G
RADIO TRANSMITTER T-303/G
VIDEO IN

NOTE.
1. SIGNAL OUTPUT IS PHYSICALLY OBTAINED FROM RECEPTACLE IN ORDER WIRE RECEIVER

TM689-243

Figure 140. Radio Set AN/TRC–29, block diagram, main signal path.

the radio receiver. The video output of the receiver is fed to suitable video equipment, which changes the signals back into their original form. The repeater station in this block diagram (fig. 140) consists of two Radio Sets AN/TRC–29 arranged to permit 2-way communication between terminals. The main signal path from the east terminal to the west terminal is identical with that described above.

c. Order-Wire Signal Path. Figure 141 shows a simplified block diagram of the order-wire signal path used in a basic radio relay system.

(1) Audio signals obtained from the handset at the west terminal are fed to the order-wire transmitter, where they are amplified and then used to frequency modulate a 6-mc subcarrier. The 6-mc fm output of the order-wire transmitter is fed to the radio transmitter in combination with the video input signals obtained from the video equipment at the west terminal. The resultant output of the radio transmitter consists of a microwave carrier that is frequency modulated by both the main video and 6-mc subcarrier signals. This composite signal then is transmitted to the antenna at the relay station as described in *b* above. The output of the radio receiver at the repeater station consists of the video portion of the microwave carrier and the modulated 6-mc subcarrier. The entire signal is fed to the order-wire receiver, which contains a 6-mc input trap. The trap extracts the modulated 6-mc subcarrier and feeds it to the circuits of the order-wire receiver, where it is amplified and detected. The video is fed to the radio transmitter as described in *b* above.

(2) The audio output of the order-wire receiver is fed to the two handsets at the relay station and also to the order-wire transmitter. At the order-wire transmitter, the audio signals are used to frequency modulate the 6-mc output of the transmitter. The 6-mc fm output of the order-wire transmitter is fed to the radio transmitter with the video signals obtained from the output of the radio receiver. The composite modulated microwave carrier of the radio transmitter then is transmitted to the east terminal. Here, the signal is fed to the radio receiver as described in *b* above. The output of the radio receiver is filtered so that the video if fed to the terminal video equipment and the 6-mc subcarrier if fed to the order-wire receiver. The audio output of the order-wire receiver is made available at the handset. Voice communication in the opposite direction (from east terminal to west terminal) is accomplished in the same manner.

(3) Telephone conversations, originating at each terminal, therefore are made available at all handsets along the radio relay system. Telephone conversations originating from the handsets at the relay station are fed to both order-wire transmitters and are therefore transmitted in both directions. Consequently, full party line facilities are available for every terminal or repeater along the route. At a repeater station, the order-wire transmitter may be modulated by either, or both, of the following audio signals: the local audio signal originating at the handset and/or the through audio signal obtained from the output of the order-wire receiver.

(4) The ringing facilities and automatic station alarm are also transmitted over the order-wire channel. The order-wire circuits of Radio Set AN/TRC–29 also provide the following services:

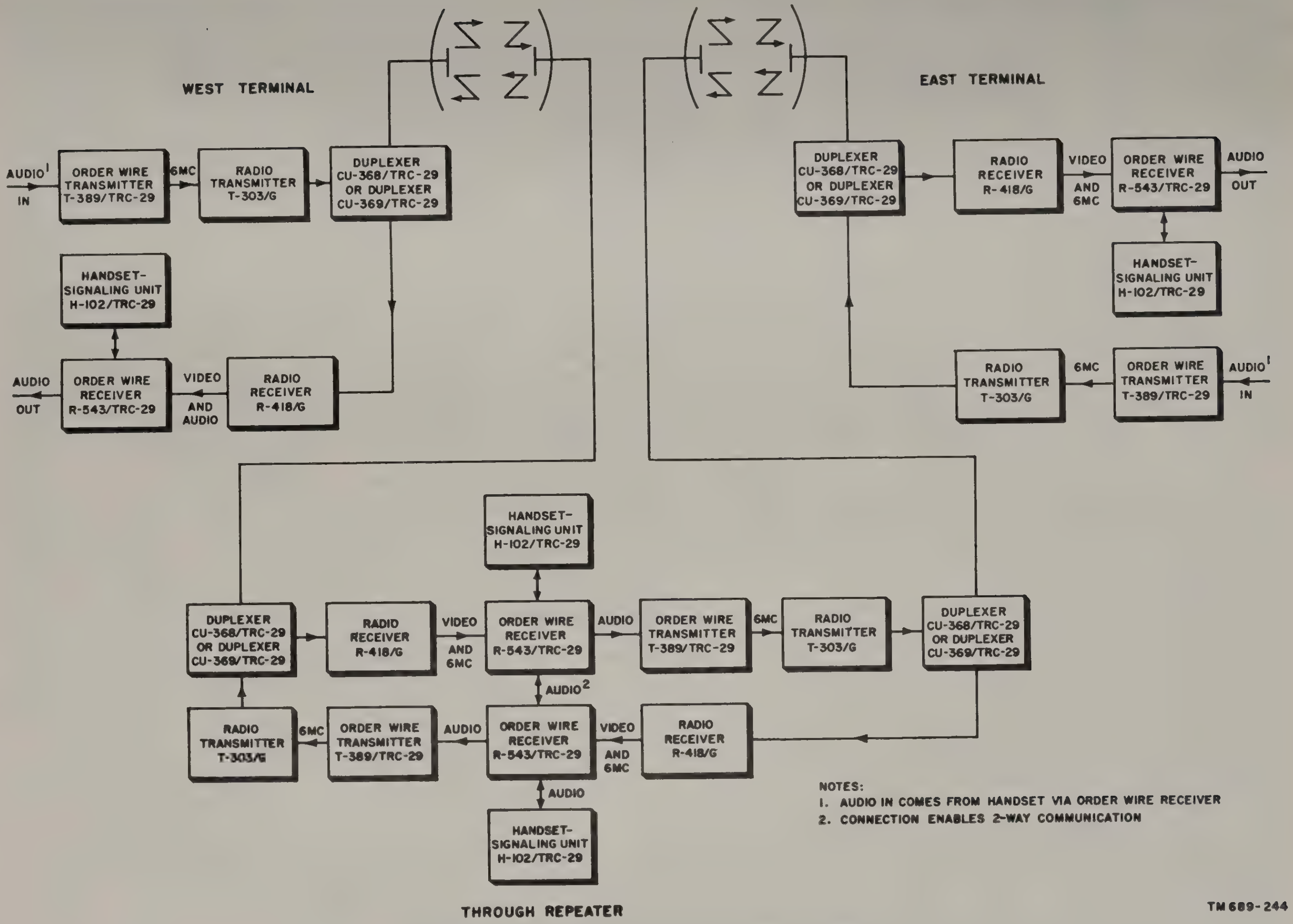
(*a*) Provision for automatic switchover.

(*b*) Sensing and control facilities for diversity reception operation.

148. Transmitting Equipment

(fig. 142)

a. The units in the transmitting equipment group include Radio Transmitter T–303/G, Order Wire Transmitter T–389/TRC–29, Power Supply PP–764/G, and Power Supply PP–689/G.


WEST TERMINAL
AUDIO[1] IN
ORDER WIRE TRANSMITTER T-389/TRC-29
6MC
RADIO TRANSMITTER T-303/G
DUPLEXER CU-368/TRC-29 OR DUPLEXER CU-369/TRC-29
HANDSET-SIGNALING UNIT H-102/TRC-29
AUDIO OUT
ORDER WIRE RECEIVER R-543/TRC-29
VIDEO AND AUDIO
RADIO RECEIVER R-418/G
EAST TERMINAL
DUPLEXER CU-368/TRC-29 OR DUPLEXER CU-369/TRC-29
RADIO RECEIVER R-418/G
VIDEO AND 6MC
ORDER WIRE RECEIVER R-543/TRC-29
AUDIO OUT
HANDSET-SIGNALING UNIT H-102/TRC-29
RADIO TRANSMITTER T-303/G
6MC
ORDER WIRE TRANSMITTER T-389/TRC-29
AUDIO[1] IN
HANDSET-SIGNALING UNIT H-102/TRC-29
DUPLEXER CU-368/TRC-29 OR DUPLEXER CU-369/TRC-29
RADIO RECEIVER R-418/G
VIDEO AND 6MC
ORDER WIRE RECEIVER R-543/TRC-29
AUDIO
ORDER WIRE TRANSMITTER T-389/TRC-29
6MC
RADIO TRANSMITTER T-303/G
DUPLEXER CU-368/TRC-29 OR DUPLEXER CU-369/TRC-29
AUDIO[2]
RADIO TRANSMITTER T-303/G
6MC
ORDER WIRE TRANSMITTER T-389/TRC-29
AUDIO
ORDER WIRE RECEIVER R-543/TRC-29
VIDEO AND 6MC
RADIO RECEIVER R-418/G
AUDIO
HANDSET-SIGNALING UNIT H-102/TRC-29
THROUGH REPEATER
TM 689-244

NOTES:
1. AUDIO IN COMES FROM HANDSET VIA ORDER WIRE RECEIVER
2. CONNECTION ENABLES 2-WAY COMMUNICATION

Figure 141. Order-wire signal path, block diagram.

b. Main-channel signals obtained from video equipment are fed to the input of the radio transmitter. Multiplexer Set AN/TCC–13 may be used as the video equipment at a terminal, or Pulse Form Restorer Group AN/TRA–10 or Multiplexer Group AN/TCA–1 at a repeater (par. 157). No video equipment is used at a through repeater. Audio signals from the local handset in the receiving equipment or from Handset-Signaling Unit H–102/TRC–29 are fed through Order Wire Receiver R–543/TRC–29 to the order-wire transmitter. Here they are used to frequency modulate a 6-mc subcarrier, which is fed to another input of the radio transmitter. In the radio transmitter, the 6-mc and main-channel video signals are combined and amplified, and then are used to frequency modulate an rf carrier in the 1,700- to 2,400-mc range. The modulated carrier is further amplified and sent through the duplexer to the antenna, to be propagated into space.

149. Receiving Equipment
(fig. 142)

a. The units in the receiving equipment group include Radio Receiver R–418/G, Order-Wire Receiver R–543/TRC–29, and Power Supply PP–690/G.

b. Signals received by the antenna are sent through the duplexer to the radio receiver, where they are amplified and detected. After further amplification, the radio receiver output, which consists of combined video and 6-mc subcarrier signals, is fed to the order-wire receiver. Here, they are first fed through a filter, which separates the video and the 6-mc subcarrier signals. The video signals are fed through an output jack to the video equipment. The video

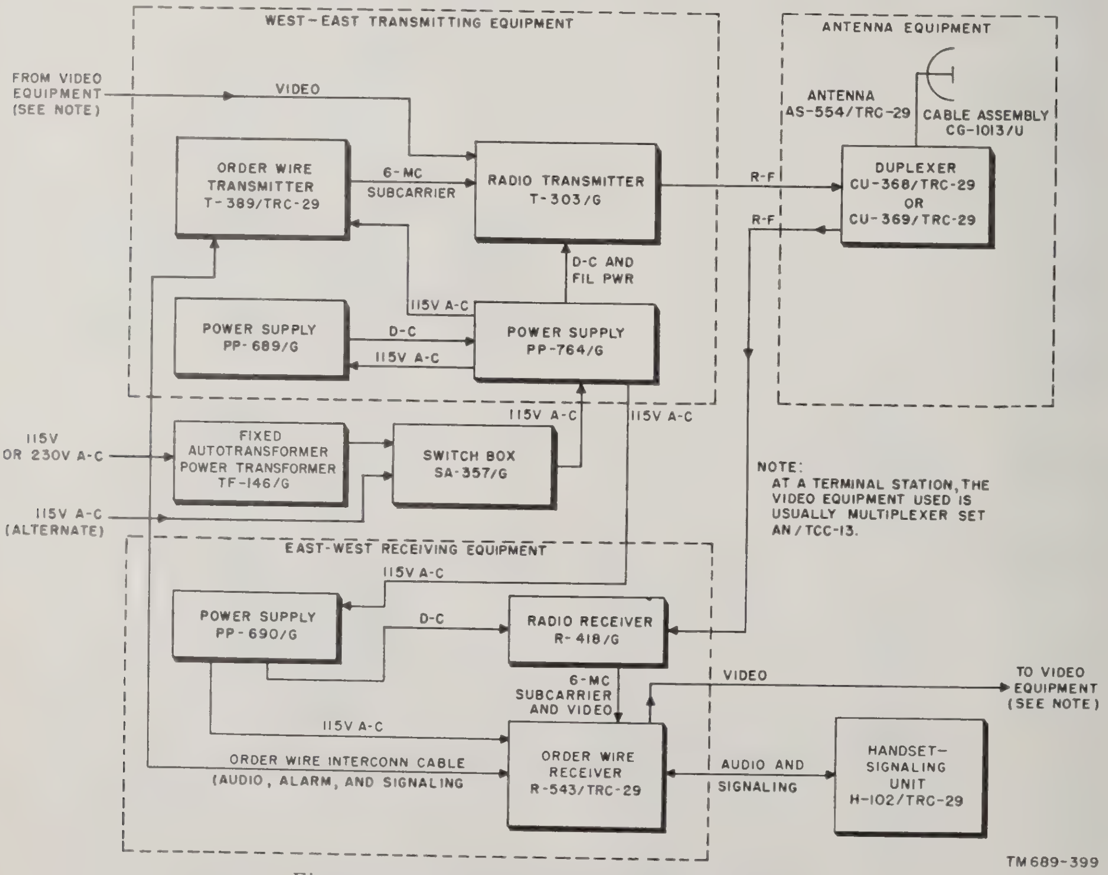

WEST–EAST TRANSMITTING EQUIPMENT
ANTENNA EQUIPMENT
FROM VIDEO EQUIPMENT (SEE NOTE)
VIDEO
ANTENNA AS-554/TRC-29
CABLE ASSEMBLY CG-1013/U
ORDER WIRE TRANSMITTER T-389/TRC-29
6-MC SUBCARRIER
RADIO TRANSMITTER T-303/G
R-F
R-F
DUPLEXER CU-368/TRC-29 OR CU-369/TRC-29
D-C AND FIL PWR
115V A-C
POWER SUPPLY PP-689/G
D-C
115V A-C
POWER SUPPLY PP-764/G
115V A-C
115V A-C
115V OR 230V A-C
FIXED AUTOTRANSFORMER POWER TRANSFORMER TF-146/G
SWITCH BOX SA-357/G
115V A-C (ALTERNATE)
NOTE: AT A TERMINAL STATION, THE VIDEO EQUIPMENT USED IS USUALLY MULTIPLEXER SET AN/TCC-13.
EAST-WEST RECEIVING EQUIPMENT
115V A-C
POWER SUPPLY PP-690/G
D-C
RADIO RECEIVER R-418/G
6-MC SUBCARRIER AND VIDEO
VIDEO
TO VIDEO EQUIPMENT (SEE NOTE)
115V A-C
ORDER WIRE INTERCONN CABLE (AUDIO, ALARM, AND SIGNALING
ORDER WIRE RECEIVER R-543/TRC-29
AUDIO AND SIGNALING
HANDSET-SIGNALING UNIT H-102/TRC-29
TM689-399

Figure 142. Radio Set AN/TRC–29 and accessories, terminal station, overall block diagram.

equipment used may be Multiplexer Set AN/TCC–13 at a terminal, and either Pulse Form Restorer Group AN/TRA–10 or Multiplexer Group AN/TCA–1 at a repeater (par. 157). At a through repeater, no video equipment is needed. The 6-mc subcarrier signals are amplified and detected. The resulting audio and signaling output is fed to the local handset or to the remote handset in Handset-Signaling Unit H–102/TRC–29 and to the local buzzer.

150. Antenna Equipment
(fig. 142)

a. The units in the antenna equipment group include Antenna AS–554/TRC–29, Duplexer CU–368/TRC–29, or Duplexer CU–369/TRC–29.

b. Radio Set AN/TRC–29 always transmits a signal of one frequency and receives a signal of another frequency; therefore, the same antenna can be used for both transmission and reception. The rf signals from the transmitter are fed through the duplexer to the antenna to be radiated into space. The rf signals received by the antenna also are fed through the duplexer, which directs them to the receiver. Thus, the duplexer distinguishes between the operating frequencies of the outgoing rf carrier and the incoming rf carrier, and directs only the desired one to the receiver.

151. Accessory Equipment

The accessory equipment furnished with Radio Set AN/TRC–29 consists of three items. Fixed Autotransformer Power Transformer TF–146/G has an adjustment handle by which the line voltage can be set manually to approximately 115 volts ac. Switch Box SA–357/G receives inputs from two line-voltage sources (usually the autotransformer output and an auxiliary power source) and selects the desired one to be fed to the radio set. Handset-Signaling Unit H–102/TRC–29 contains facilities for party line ringing, initiating outgoing signals, and receiving incoming signals. It can be connected to the order-wire receiver for use as a remote handset.

152. Signaling and Ringing Facilities

The order-wire channel carries the ringing and alarm signals and also serves as a speech channel. To hear audible signals, a bell is provided on the remote handset and a buzzer in the order-wire receiver. Outgoing ringing signals are initiated by pressing either the ringing button provided on the remote handset, or a similar button on the order-wire receiver. Each time either button is pressed, a ring pulse is transmitted to every station in the radio relay system. Rings longer than 1 second will be cut off.

153. Alarm and Transfer Control Facilities

a. When an abnormal condition occurs in the receiving equipment, a continuous alarm is set off at the station in which the fault exists. When the fault occurs in the transmitting equipment, the continuous alarm sounds in the receiving equipment of the following station. In addition, a 2-second alarm signal is transmitted to all stations *following* the faulty station, from there to the terminal. Stations preceding the defective station, in the direction of the signal travel, receive no alarm signal.

b. The alarm circuits are actuated if either of two conditions occurs: if the signal-to-noise ratio of the received signal falls below a predetermined level, or if a failure causing disappearance of the signal occurs in any radio or order-wire transmitter or receiver in the relay system.

c. When an alarm circuit is actuated as described above and if transfer control equipment is in use, connections between it and all pertinent components of the equipment will, after a short period of time, transfer operation to standby transmitting and receiving equipment.

154. Power Distribution Facilities

All primary line power for the equipment is fed through Power Supply PP–764/G, which distributes the power to all units requiring it. Power Supply PP–689/G furnishes the low-potential dc voltages for the radio transmitter; and it connects them to Power Supply PP–764/G, which feeds them to the radio transmitter, together with filament voltages and the high-potential dc voltages. Power Supply PP–690/G furnishes all the filament and dc voltages required by the radio receiver. The order-wire transmitter and receiver are equipped with self-contained power supplies.

155. Testing and Monitoring Facilities

Testing, metering, and monitoring facilities, built into the equipment, provide for constant monitoring of some signals in the equipment and for convenient routine maintenance checking of others. These include audio signals, modulation levels, order-wire subcarrier level, modulator input and output signals, limiter and discriminator operating levels, and other voltages and currents at vital points within the equipment.

156. Terminal Station

The basic equipment used at a terminal station is shown on figure 142. A terminal station requires one set of transmitting equipment, one set of receiving equipment, one set of antenna equipment, and one set of accessory equipment. A set of standby equipment should be available for emergencies.

157. Repeater Station
(fig. 143)

There are two general types of repeater stations used in the microwave radio relay system. They are called a *through* repeater station and a *drop-channel* repeater station. In a through repeater station, the signals obtained from the output of the receiver are fed directly to the following transmitter to be retransmitted for the next hop. Drop-channel repeater stations are equipped with video drop and insert facilities, which permit certain of the multiplexed video channels to be dropped at the station, on a party line or terminating basis, instead of continuing at the terminal. Intelligence initiated at the drop-channel repeater station also may be inserted in these channels in the multichannel signal on an east-talking, west-talking, or party line basis. Equipment such as Pulse Form Restorer Group AN/TRA–10 or Multiplexer Group AN/TCA–1 may be used.

a. The equipment required for a through repeater consists of two complete Radio Sets AN/TRC–29, connected *back-to-back* (fig. 143). Radio set A includes the east-west transmitting equipment and the west-east receiving equipment. Radio set B includes the west-east transmitting equipment and the east-west receiving equipment. An additional repeater interconnection cable, interconnecting the two sets of receiving equipment, is used at a repeater station for audio, alarm, signaling, and control purposes in both directions.

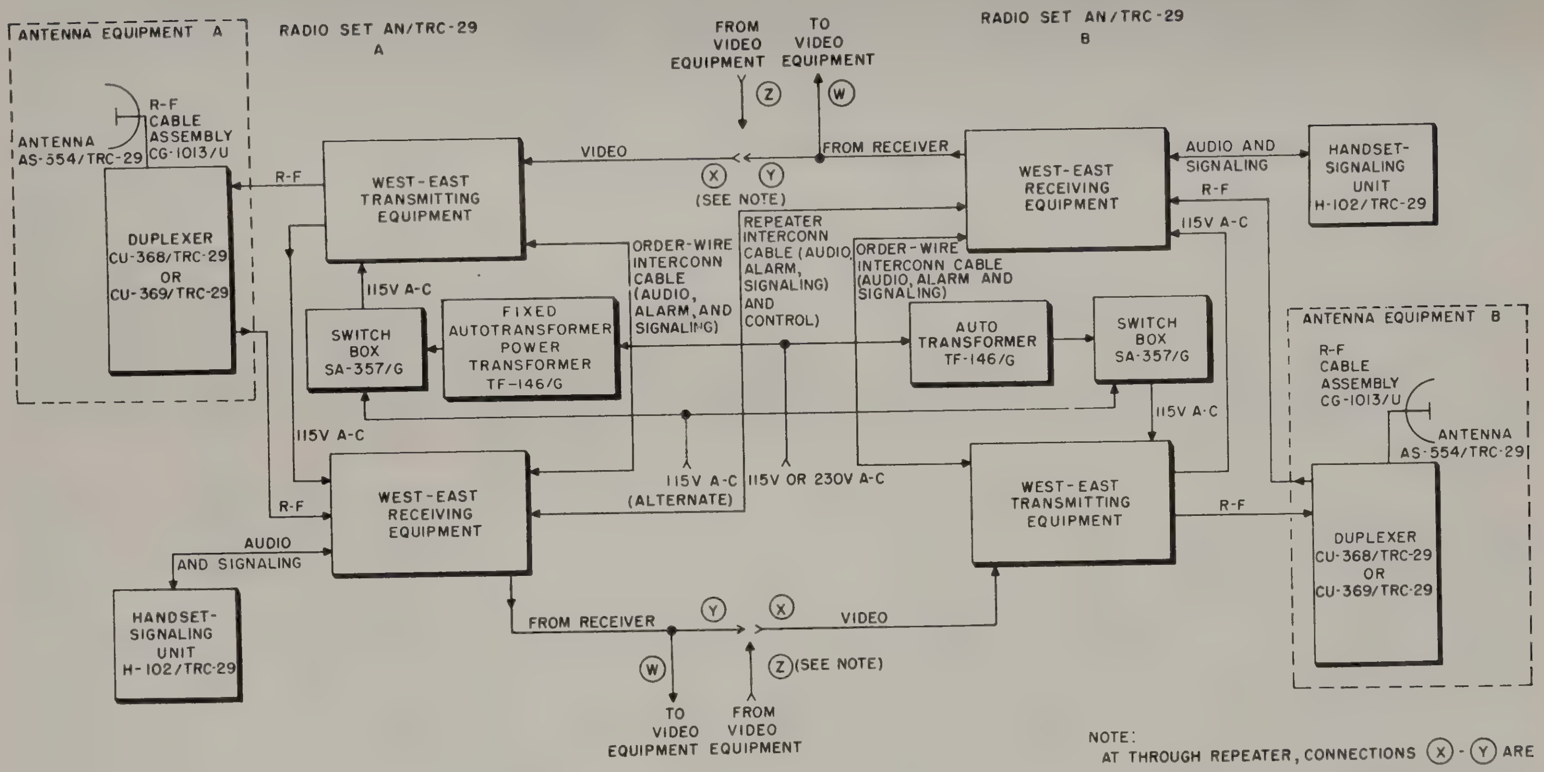
b. At a drop-channel repeater station, the same radio set equipment is used, with additional video equipment as described above. Alternate connections for this equipment are shown on figure 143.

158. Diversity-Operated Station
(fig. 144)

At some stations, where difficult topographic or atmospheric conditions are found, diversity operation is used to overcome the effects of signal fading. An additional receiver and receiving antenna are used. Where diversity operation is used in only one direction, the regular standby receiver usually is used. Where diversity operation is needed in both directions, an additional set of receiving and antenna equipment, or an additional Radio Set AN/TRC–29, must be obtained. One receiver is the preferred receiver; the other is the standby receiver. Automatic switching circuits are incorporated in the receivers, which select the receiver that has the best signal-to-noise ratio and its video output is used for retransmission. This may be either the preferred or the standby receiver. Special diversity interconnection and video cables tie the signal, operating, and control circuits of the two receivers together.

159. Organization of Material Covering Transmitting and Receiving Equipment

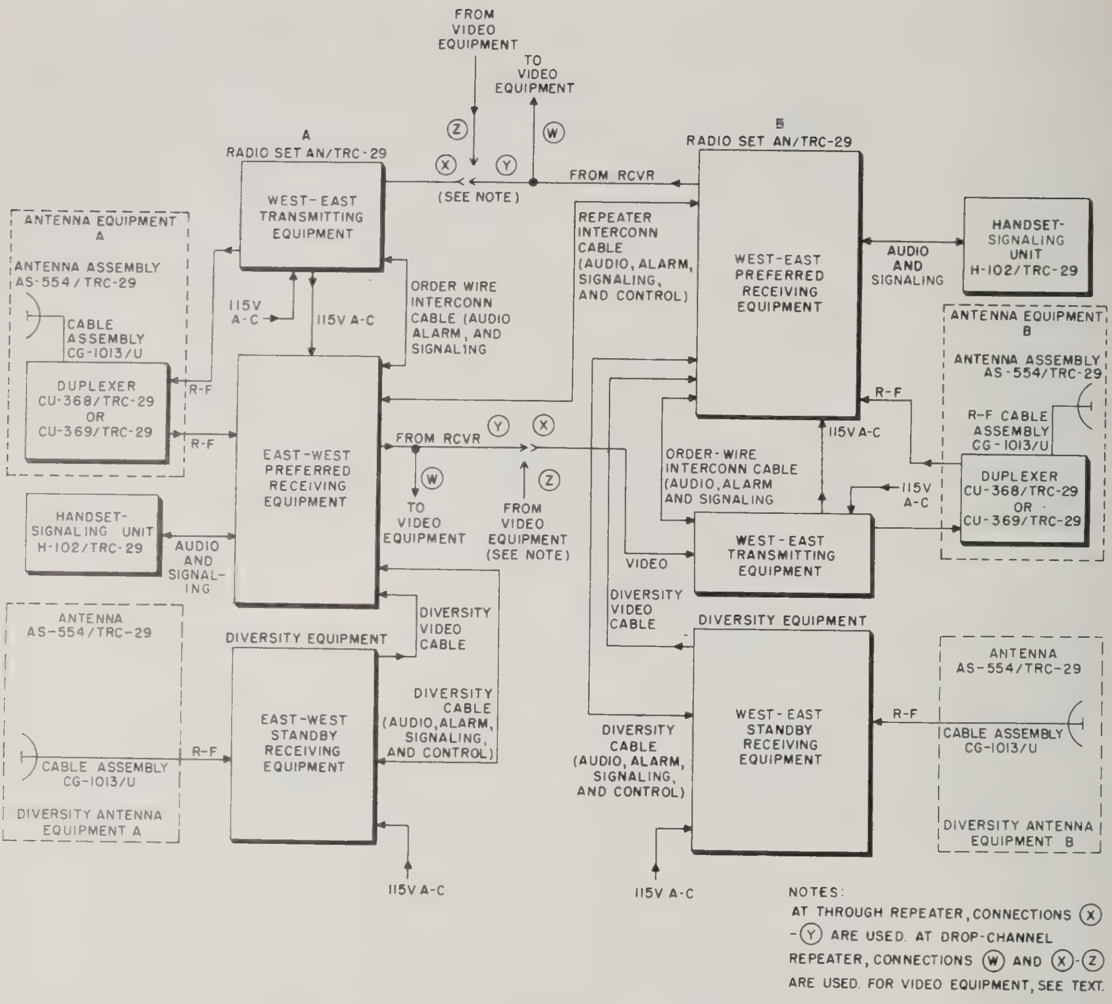
The detailed description of the transmitting and receiving equipment is arranged as follows: an overall description of the transmitting (or receiving) equipment is followed by a general block-diagram description at the major unit or circuit-group level. Next, each of the blocks previously covered is further broken down, first in stage-by-stage or function-by-function block form, and finally a complete description of the circuit details is given in each case. The next block is treated in the same manner, and so on. This means starting at the top level, then working down level by level, through equipment, major unit, subchassis, etc., to the individual circuit.


ANTENNA EQUIPMENT A
RADIO SET AN/TRC-29
A
R-F
CABLE
ASSEMBLY
CG-1013/U
ANTENNA
AS-554/TRC-29
DUPLEXER
CU-368/TRC-29
OR
CU-369/TRC-29
R-F
WEST-EAST
TRANSMITTING
EQUIPMENT
VIDEO
FROM
VIDEO
EQUIPMENT
TO
VIDEO
EQUIPMENT
Z
W
FROM RECEIVER
X
Y
(SEE NOTE)
RADIO SET AN/TRC-29
B
WEST-EAST
RECEIVING
EQUIPMENT
AUDIO AND
SIGNALING
R-F
115V A-C
HANDSET-
SIGNALING
UNIT
H-102/TRC-29
115V A-C
SWITCH
BOX
SA-357/G
FIXED
AUTOTRANSFORMER
POWER
TRANSFORMER
TF-146/G
ORDER-WIRE
INTERCONN
CABLE
(AUDIO,
ALARM, AND
SIGNALING)
REPEATER
INTERCONN
CABLE (AUDIO,
ALARM,
SIGNALING)
AND
CONTROL)
ORDER-WIRE
INTERCONN CABLE
(AUDIO, ALARM AND
SIGNALING)
AUTO
TRANSFORMER
TF-146/G
SWITCH
BOX
SA-357/G
ANTENNA EQUIPMENT B
R-F
CABLE
ASSEMBLY
CG-1013/U
ANTENNA
AS-554/TRC-29
115V A-C
115V A-C
115V A-C
(ALTERNATE)
115V OR 230V A-C
R-F
WEST-EAST
RECEIVING
EQUIPMENT
WEST-EAST
TRANSMITTING
EQUIPMENT
R-F
DUPLEXER
CU-368/TRC-29
OR
CU-369/TRC-29
AUDIO
AND SIGNALING
HANDSET-
SIGNALING
UNIT
H-102/TRC-29
FROM RECEIVER
Y
X
VIDEO
W
Z
(SEE NOTE)
TO
VIDEO
EQUIPMENT
FROM
VIDEO
EQUIPMENT

NOTE:
AT THROUGH REPEATER, CONNECTIONS Ⓧ - Ⓨ ARE USED. AT DROP-CHANNEL REPEATER, CONNECTIONS Ⓦ AND Ⓧ - Ⓩ ARE USED. FOR VIDEO EQUIPMENT USED, SEE TEXT.

TM 689-400

Figure 143. Repeater station equipment, block diagram.


FROM VIDEO EQUIPMENT
TO VIDEO EQUIPMENT
Z
W
X
Y
(SEE NOTE)
A
RADIO SET AN/TRC-29
B
RADIO SET AN/TRC-29
FROM RCVR
WEST-EAST TRANSMITTING EQUIPMENT
ANTENNA EQUIPMENT A
ANTENNA ASSEMBLY AS-554/TRC-29
CABLE ASSEMBLY CG-1013/U
DUPLEXER CU-368/TRC-29 OR CU-369/TRC-29
R-F
R-F
115V A-C
115V A-C
ORDER WIRE INTERCONN CABLE (AUDIO ALARM, AND SIGNALING
REPEATER INTERCONN CABLE (AUDIO, ALARM, SIGNALING, AND CONTROL)
WEST-EAST PREFERRED RECEIVING EQUIPMENT
AUDIO AND SIGNALING
HANDSET-SIGNALING UNIT H-102/TRC-29
ANTENNA EQUIPMENT B
ANTENNA ASSEMBLY AS-554/TRC-29
R-F
R-F CABLE ASSEMBLY CG-1013/U
DUPLEXER CU-368/TRC-29 OR CU-369/TRC-29
115V A-C
115V A-C
EAST-WEST PREFERRED RECEIVING EQUIPMENT
FROM RCVR
Y
X
W
Z
TO VIDEO EQUIPMENT
FROM VIDEO EQUIPMENT (SEE NOTE)
ORDER-WIRE INTERCONN CABLE (AUDIO, ALARM AND SIGNALING
HANDSET-SIGNALING UNIT H-102/TRC-29
AUDIO AND SIGNAL-ING
VIDEO
WEST-EAST TRANSMITTING EQUIPMENT
ANTENNA AS-554/TRC-29
DIVERSITY EQUIPMENT
DIVERSITY VIDEO CABLE
DIVERSITY VIDEO CABLE
DIVERSITY EQUIPMENT
EAST-WEST STANDBY RECEIVING EQUIPMENT
DIVERSITY CABLE (AUDIO, ALARM, SIGNALING, AND CONTROL)
R-F
CABLE ASSEMBLY CG-1013/U
DIVERSITY ANTENNA EQUIPMENT A
DIVERSITY CABLE (AUDIO, ALARM, SIGNALING, AND CONTROL)
WEST-EAST STANDBY RECEIVING EQUIPMENT
R-F
ANTENNA AS-554/TRC-29
CABLE ASSEMBLY CG-1013/U
DIVERSITY ANTENNA EQUIPMENT B
115V A-C
115V A-C

NOTES:
AT THROUGH REPEATER, CONNECTIONS Ⓧ-Ⓨ ARE USED. AT DROP-CHANNEL REPEATER, CONNECTIONS Ⓦ AND Ⓧ-Ⓩ ARE USED. FOR VIDEO EQUIPMENT, SEE TEXT.

TM 689-401

Figure 144. Two-way diversity equipment at repeater station, block diagram.

160. Diagrams Pertaining to Theory Chapter

The block diagrams and simplified schematic diagrams for each of the subjects discussed are placed at those points in the text where their major portions are covered. For overall diagrams such as interconnection, cabling, and complete schematic diagrams, refer to the group of illustrations at the back of this manual.

Section II. TRANSMITTING EQUIPMENT

161. Overall Description

(fig. 145)

The transmitting equipment of Radio Set AN/TRC–29 consists of Radio Transmitter T–303/G, Order-Wire Transmitter T–389/TRC–29, Power Supply PP–764/G, and Power Supply PP–689/G.

a. Radio Transmitter T–303/G.

(1) Radio Transmitter T–303/G (par. 162) accepts video signals in the 30-

cps to 4.5-mc band, as well as a 6-mc order-wire subcarrier, and uses them to frequency modulate an rf carrier in the 1,700- to 2,400-mc band. This intelligence is sent through a transmission line to the antenna, which radiates it into space. The bandwidth of the transmitter extends from 30 cps to approximately 6 mc. A 100-kc portion of this band, located at 6 mc, is assigned to the order-wire subcarrier, while the 30-cps to 4.5-mc portion is reserved for the main traffic signals. The bandwidth of the externally generated video signal to be transmitted must, therefore, be limited to 4.5 mc to eliminate any signals in the 6-mc region that might interfere with the order-wire subcarrier. An input video filter that attenuates frequencies above 4.5 mc is provided to accomplish this. The video filter is used at a signal-originating station, including stations that use Pulse Form Restorer Group AN/TRA–10 or Multiplexer Group AN/TCA–1 equipment, but is unnecessary at through repeater stations, because a similar filter is included as part of the receiving equipment (par. 174*c*).

(2) The transmitter is continuously tunable over the frequency range 1,700 to 2,400 mc. However, the transmitter normally is operated on one of 27 channel frequencies for which frequency-control crystals are available. The rf bandwidth, including the order-wire subcarrier, is approximately 15 mc.

(3) The circuits incorporated in the main transmitter to perform the functions described above include: a video modulator, a modulated rf oscillator, and an rf amplifier. In addition, it contains auxiliary operating circuits, such as afc to maintain the desired carrier frequency, an electronic voltage regulator for the rf oscillator, and alarm control circuits for continuously monitoring the signal path. Also contained in the transmitter are built-in test circuits and facilities to expedite alinement, troubleshooting, and evaluation of the performance of the equipment during operation. These facilities include a sawtooth generator, monitor receiver, peak vtvm, and metering equipment.

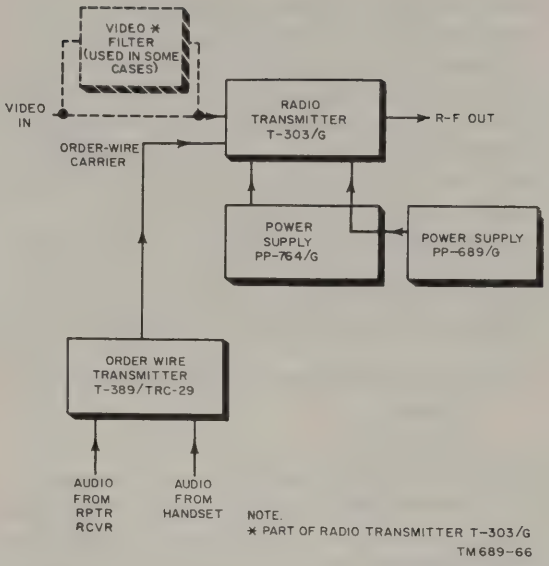

VIDEO * FILTER (USED IN SOME CASES)
VIDEO IN
ORDER-WIRE CARRIER
RADIO TRANSMITTER T-303/G
R-F OUT
POWER SUPPLY PP-764/G
POWER SUPPLY PP-689/G
ORDER WIRE TRANSMITTER T-389/TRC-29
AUDIO FROM RPTR RCVR
AUDIO FROM HANDSET
NOTE.
* PART OF RADIO TRANSMITTER T-303/G
TM689-66

Figure 145. Transmitting equipment, block diagram.

b. Order-Wire Transmitter T–389/TRC–29. The order-wire transmitter accepts speech signals from the handset (in the order-wire receiver) if the transmitter is at a terminal or, if it is at a repeater station, accepts such signals from either the handset or the audio output of the preceding order-wire receiver, and uses them to frequency modulate a 6-mc order-wire subcarrier. This vf modulated rf subcarrier, containing the order-wire channel intelligence, is fed into the main transmitter video circuits in the first stage of the modulator. The order-wire transmitter also contains auxiliary circuits, including afc, a test-tone oscillator, and metering facilities. In conjunction with signaling equipment in the order-wire receiver (part of the receiving equipment), it provides carrier-keying for the order-wire channel. Ringing and talking on the order-wire channel are on a party line basis. Paragraph 171 details the circuitry of the order-wire transmitter.

c. Power Supply PP–764/G. Power for Radio Transmitter T–303/G is furnished by two power supplies. Power Supply PP–764/G provides high-voltage dc for the transmitter rf circuits and filament power for all of the transmitter circuits. It also functions as a distribution center for low dc voltages for the transmitter, which are obtained from Power Supply PP–689/G, besides distributing primary line power for both the transmitter and receiver of Radio Set AN/TRC–29. Details of this power supply are covered in paragraph 172.

d. Power Supply PP–689/G. Power Supply PP–689/G (par. 173) provides several regulated low-voltage dc outputs for portions of the transmitter other than the rf generator circuits.

162. Radio Transmitter T–303/G, Block Diagram

(fig. 146)

a. In the radio transmitter, the video and 6-mc order-wire subcarrier signals are applied to the grid and cathode, respectively, of the first video amplifier in the modulator. The combined video signal obtained at the output of this stage is passed through four additional stages of video amplification, providing a level sufficient to modulate the klystron oscillator in the rf generator. The output of the modulator is applied to the klystron rf oscillator, the frequency of which varies in accordance with the amplitude of the modulating signal. The fm output of the klystron is fed through the power amplifier to the antenna.

b. A portion of the power amplifier output is fed to the afc circuits, which stabilize the klystron at the desired center (carrier) frequency. This portion of the power amplifier output is mixed with the output of a crystal-controlled oscillator-multiplier. The oscillator harmonic signal chosen is 120 mc higher than that of the 1,700- to 2,400-mc klystron rf carrier frequency. Consequently, a 120-mc if. signal is obtained at the output of the crystal mixer. This signal is amplified in an if. amplifier, acted on by limiters, and fed to a discriminator. Part of the dis-

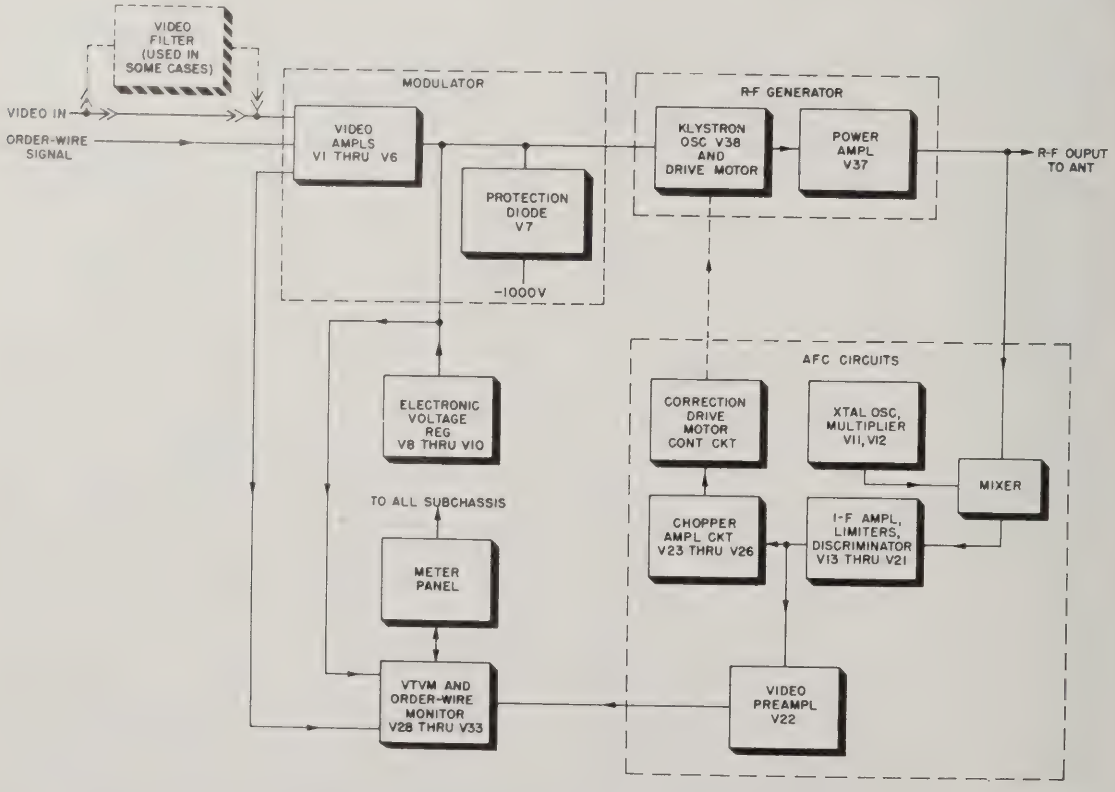

VIDEO FILTER (USED IN SOME CASES)
MODULATOR
VIDEO IN
ORDER-WIRE SIGNAL
VIDEO AMPLS V1 THRU V6
PROTECTION DIODE V7
-1000V
R-F GENERATOR
KLYSTRON OSC V38 AND DRIVE MOTOR
POWER AMPL V37
R-F OUPUT TO ANT
ELECTRONIC VOLTAGE REG V8 THRU V10
AFC CIRCUITS
CORRECTION DRIVE MOTOR CONT CKT
XTAL OSC, MULTIPLIER V11, V12
MIXER
TO ALL SUBCHASSIS
CHOPPER AMPL CKT V23 THRU V26
I-F AMPL, LIMITERS, DISCRIMINATOR V13 THRU V21
METER PANEL
VTVM AND ORDER-WIRE MONITOR V28 THRU V33
VIDEO PREAMPL V22
TM689-67

Figure 146. Radio Transmitter T–303/G, block diagram.

criminator output is amplified by a video preamplifier for monitoring and metering. If the klystron carrier frequency deviates from its normal value, the afc discriminator output also contains a dc component. This dc component is chopped and amplified by a chopper and chopper-amplifier circuit and applied to a correction drive motor in the klystron assembly. The motor mechanically retunes the klystron to eliminate the dc component in the afc discriminator output. Thus, the output of the klystron is stabilized automatically at the desired carrier frequency. The reflector voltage for the klystron is held constant by the electronic voltage regulator. Significant voltages are monitored by the vtvm and the meters on the meter panel.

163. Video Filter
(fig. 147)

a. At signal-originating stations, the video-signal input to the modulator is fed through a low pass video filter. The video filter has a pass band from 0 to 4.5 mc. Above 4.5 mc, signal attenuation through the filter increases rapidly. At 6 mc, the output of the filter is at least 35 db down, or zero for all practical purposes. The video-signal output of the filter, which is fed to the transmitter, has no significant components at 6 mc, the frequency of the order-wire subcarrier signal. This arrangement keeps video components from entering the order-wire channel and causing cross talk. Its use at repeater stations is not required because all signals reaching a repeater station pass through a similar filter that is a part of the order-wire receiver. For further details on the filter, refer to paragraph 185*a*.

b. The filter consists of a shunt m-derived T-section. This section contains capacitors C1, C2, and C3 and inductors L1 and L2. The filter network is terminated by resistors R1 and R2 in the modulator input circuit.

c. When the filter is used, the input video signal cable is connected to the VIDEO FILTER INPUT jack, and the VIDEO FILTER OUTPUT plug is connected to the VIDEO INPUT jack in the modulator. When the filter is not used, the input video signal cable is connected directly to the modulator VIDEO INPUT jack.

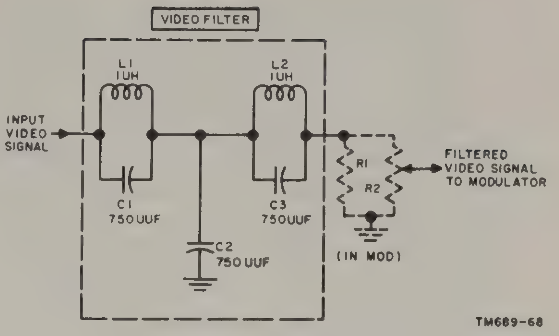


Figure 147. Video filter, simplified schematic diagram.

164. Modulator
(fig. 148)

a. General. The modulator is a video amplifier with a voltage gain of approximately 400 for signal frequencies between 30 cps and 6 mc. It amplifies low-level video input signals to the proper level for application to the transmitter oscillator so that the carrier deviations of ±3.6 mc are obtained for 100 percent modulation. The main traffic video signals are fed to the modulator through rf cable W2, which is connected to VIDEO INPUT receptacle J14. The order-wire subcarrier generated by Order-Wire Transmitter T–389/TRC–29 is fed to the modulator through rf cable W3, which is connected to OW CARR INPUT receptacle J15. SAWTOOTH INPUT receptacle J2 is provided for applying a sawtooth test signal to the modulator. The output of the modulator is fed to the klystron oscillator through wire W4. Some of the components of the klystron oscillator circuit and testing circuits are mounted on the modulator for convenience though not functionally a part of it. The modulator can be divided into four functional blocks as follows:

(1) Input selector.
(2) First feedback-amplifier section.
(3) Second feedback-amplifier section.
(4) Protection diode and output circuit.

b. Block Diagram Description.

(1) *Input selector.* The desired modulator input is selected by MOD INPUT SEL SW S1. The order-wire subcarrier is not connected to the modulator input through S1, but is fed to the modulator regardless of the position of S1.

(2) *First feedback-amplifier section.* The first feedback-amplifier section con-

sists of two 2C51 dual triodes (V1 and V2) acting as video amplifiers. With switch S1 in its normal VID position, the main traffic video signals are fed to the grid of first stage V1A and the order-wire signals are fed to the cathode of that stage. The output video signal, consisting of both the main traffic and order-wire signals, is fed through V1B, the cathode output of which is further amplified by the second stage, V2A. The V2A plate signal is coupled to the grid of V2B. The video output from the cathode of V2B is coupled to the input of the second feedback amplifier. Overall degenerative feedback for stabilizing the gain of these stages is accomplished by feeding back a portion of the output of V2B to the cathode of V1A.

(3) *Second feedback-amplifier section.* The second feedback-amplifier section consists of three stages of video amplification. The video signal from V2B in the first feedback-amplifier section is amplified by the third video amplifier, V3, which is a 6AG7 pentode. Further amplification of the video signal takes place in the fourth video amplifier, which uses two 6AG7 pentodes, V4 and V5, connected in parallel. The output of V4 and V5 is fed to the final, or fifth, stage of amplification, V6, which is an 829B twin tetrode with both tetrode sections connected in parallel. Overall degenerative feedback is obtained by feeding back a portion of the cathode voltage of V6 to the cathode of V3. The degenerative feedback effectively stabilizes the gain of the amplifier. The output of V6 is connected to the klystron oscillator reflector cap.

(4) *Protection diode.* The protection diode circuit is a 6X4W diode, V7, provided to prevent the reflector electrode of the

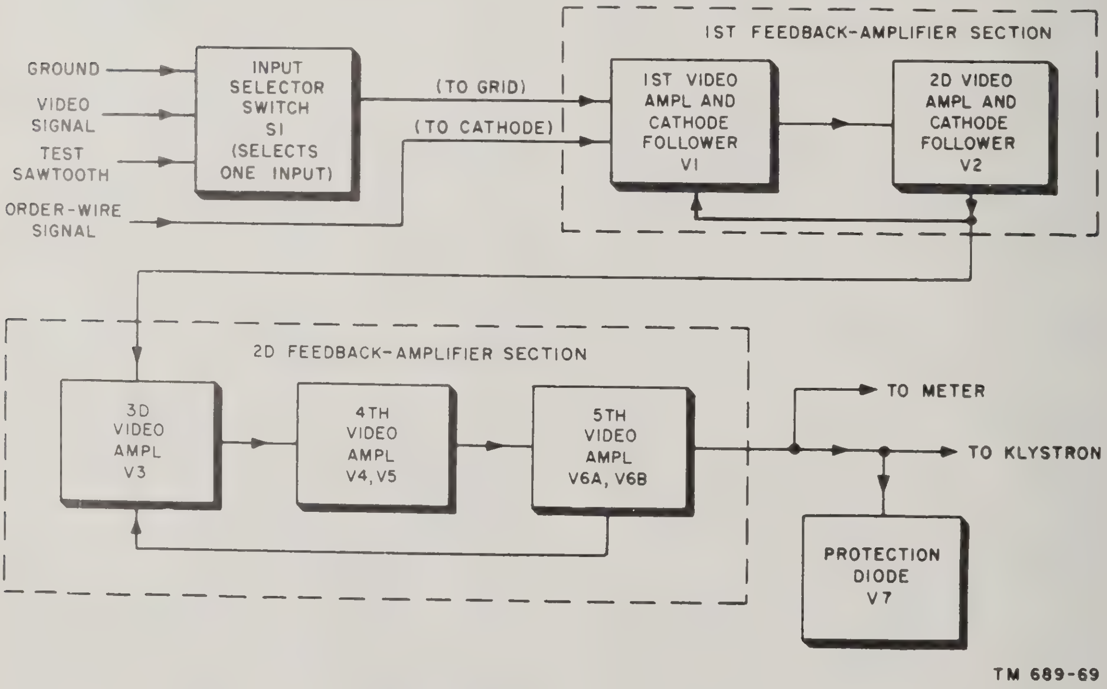

GROUND
VIDEO SIGNAL
TEST SAWTOOTH
ORDER-WIRE SIGNAL
INPUT SELECTOR SWITCH S1 (SELECTS ONE INPUT)
(TO GRID)
(TO CATHODE)
1ST FEEDBACK-AMPLIFIER SECTION
1ST VIDEO AMPL AND CATHODE FOLLOWER V1
2D VIDEO AMPL AND CATHODE FOLLOWER V2
2D FEEDBACK-AMPLIFIER SECTION
3D VIDEO AMPL V3
4TH VIDEO AMPL V4, V5
5TH VIDEO AMPL V6A, V6B
TO METER
TO KLYSTRON
PROTECTION DIODE V7
TM 689-69

Figure 148. Modulator, block diagram.

klystron from becoming positive with respect to its beam electrode.

c. Detailed Circuit Description.

(1) *Input selector circuit* (fig. 149). MOD INPUT SEL SW S1 selects the input signal that is applied to the grid of V1A. In position 1 (GND), the grid of V1A is grounded for video. This position is selected to check the radio transmitter rf sections with no external modulation present. In position 2 (VID), the external video input across R1 is connected through VIDEO LEVEL control R2 to the grid of V1A in the first feedback-amplifier section. Resistor R2 is adjusted for the desired fm deviation of the rf carrier, which is determined by the video-signal amplitude. In position 3 (ST), a sawtooth-oscillator deviation test signal is connected to the grid of V1A instead of the external video signal. The sawtooth signal is a standard test signal used to check radio transmitter deviation with simulated modulation present. The radio transmitter cannot transmit any main-traffic signal unless the MOD INPUT SEL SW is in position 2, applying a video-signal input to the modulator. The order-wire signal is fed directly to the cathode of V1A, and consequently is not controlled by switch S1 or the video level control.

(2) *First feedback-amplifier section, V1 and V2* (fig. 150). The first feedback-amplifier section consists of two video amplifier stages, each employing a 2C51 dual triode. The overall voltage gain of the first feedback-amplifier section is about 12.

(*a*) *First video amplifier V1.* Assume that a video-signal input is selected by switch S1. The signal is applied through coupling capacitor C4 and across grid load resistor R3, to the grid of V1A. The order-wire input signal is applied through R8 to the cathode of this stage by a voltage-divider network, R4 and R9. Both signals are amplified by V1A and appear across plate load resistor R5. Resistor R5 is connected to the +250-volt supply through resistors R6 and R13, which form decoupling networks with bypass capacitors C5 and C7. The voltage developed across plate load resistor R5 is coupled through capacitor C6 to the grid of cathode follower V1B. The output developed across cathode load resistors R10 and R11 is fed to the grid of V2A. The use of low-impedance cathode followers permits stable operation and improved response over a wide band of frequencies. Grid load resistor R12 is connected to the junction of R10 and R11 to provide proper grid bias.

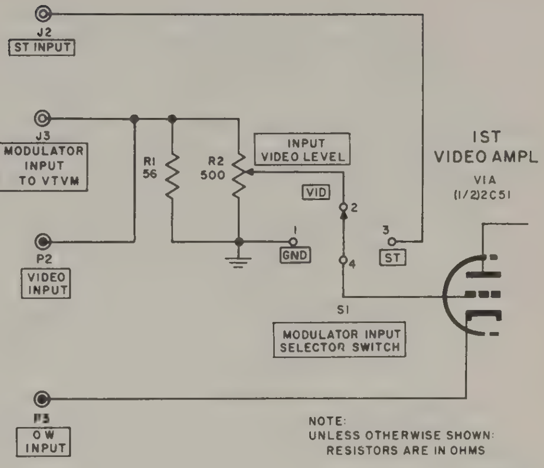


Figure 149. Input selector circuit, simplified schematic diagram.

Note. For Radio Transmitter T–303/G on Order No. 1640–Phila–51 (serial No. 57–297) and Order No. 15739–Phila–55 (serial No. 298–417), the values of resistors R5 and R15 have been changed from 2,200 ohms to 2,400 ohms. The values of these resistors were increased to eliminate the tendency for parasitic oscillations.

(*b*) *Second video amplifier V2.* The output of the first video amplifier is applied to V2A through coupling capacitor C8. The amplified voltage appearing across plate load resistor R15 is applied through C11 to the grid of V2B. Video bypassing is provided by C9 and decoupling by R16 and R13. Tube V2B is a cathode follower, with the output developed across voltage divider R19, R20, and R9 being fed to V3. Cathode resistor R9 also provides the feedback voltage ((*c*) below).

(*c*) *Feedback circuit.* Resistor R9 is common to both V1A and V2B. A portion of the video output signal developed in the cathode circuit of V2B appears across R9, which is also in the cathode circuit of V1A. This feedback voltage is degenerative with respect to the video signal fed to the grid of V1A, because the voltage fed back to the cathode of V1A is in phase with that at its grid, and acts to minimize any change in grid-cathode voltage. The degenerative feedback voltage tends to maintain a constant voltage gain for the first feedback-amplifier section, because any increase of gain of an individual stage increases the feedback signal, which effectively decreases the input signal over the entire band amplified by the two stages. Capacitor C10, which bypasses resistor R20, increases the feedback at the higher video frequencies to compensate for the cathode circuit (tube input) capacitance.

(3) *Second feedback-amplifier section, V3 through V6* (fig. 151). The second feedback-amplifier section consists of three video amplifiers, V3 through V6. The overall voltage gain of the second feedback-amplifier section is about 32.

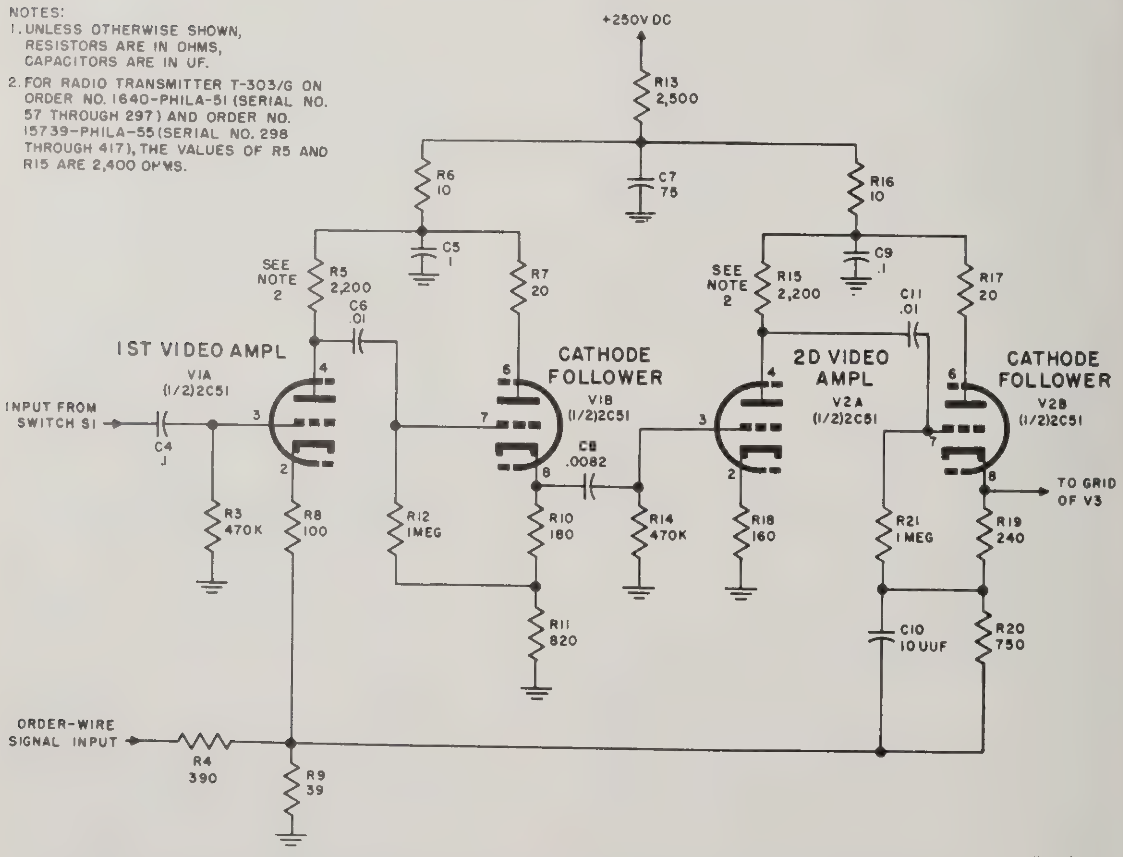
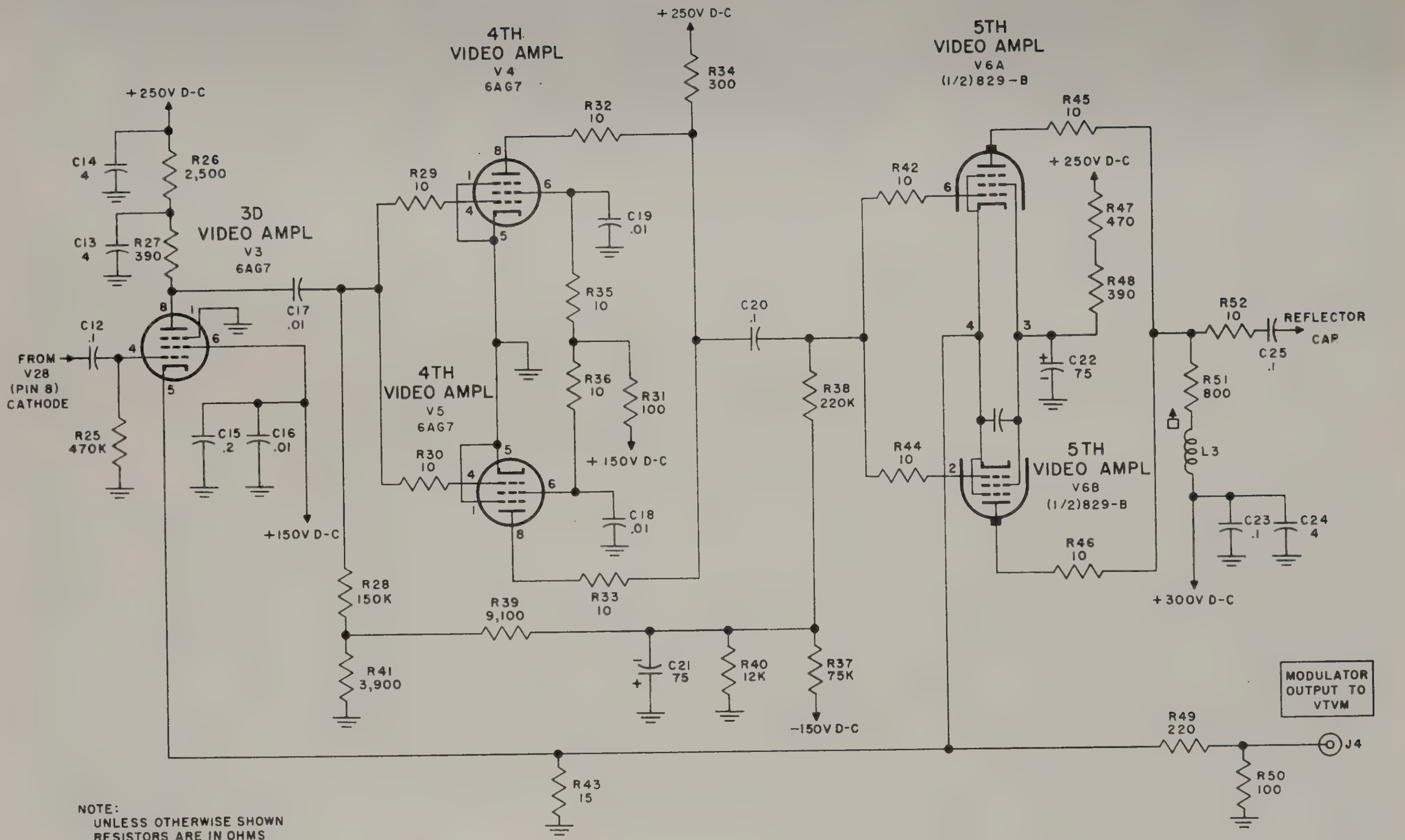

NOTES:
1. UNLESS OTHERWISE SHOWN, RESISTORS ARE IN OHMS, CAPACITORS ARE IN UF.
2. FOR RADIO TRANSMITTER T-303/G ON ORDER NO. 1640-PHILA-51 (SERIAL NO. 57 THROUGH 297) AND ORDER NO. 15739-PHILA-55 (SERIAL NO. 298 THROUGH 417), THE VALUES OF R5 AND R15 ARE 2,400 OHMS.
+250V DC
R13 2,500
R6 10
C7 75
R16 10
C5 1
C9 .1
SEE NOTE 2
R5 2,200
R7 20
SEE NOTE 2
R15 2,200
C11 .01
R17 20
C6 .01
1ST VIDEO AMPL
V1A (1/2)2C51
CATHODE FOLLOWER
V1B (1/2)2C51
2D VIDEO AMPL
V2A (1/2)2C51
CATHODE FOLLOWER
V2B (1/2)2C51
INPUT FROM SWITCH S1
C4 .1
C8 .0082
TO GRID OF V3
R3 470K
R8 100
R12 1MEG
R10 180
R14 470K
R18 160
R21 1MEG
R19 240
R11 820
C10 10UUF
R20 750
ORDER-WIRE SIGNAL INPUT
R4 390
R9 39
TM 689-87

Figure 150. First feedback-amplifier section, V1 and V2, simplified schematic diagram.


+250V D-C
C14
4
R26
2,500
C13
4
R27
390
3D
VIDEO AMPL
V3
6AG7
C12
.1
FROM
V28
(PIN 8)
CATHODE
R25
470K
C15
.2
C16
.01
+150V D-C
C17
.01
4TH
VIDEO AMPL
V4
6AG7
R29
10
R32
10
C19
.01
R35
10
R36
10
R31
100
+150V D-C
4TH
VIDEO AMPL
V5
6AG7
R30
10
C18
.01
R33
10
+250V D-C
R34
300
R28
150K
R39
9,100
R41
3,900
C21
75
R40
12K
R37
75K
-150V D-C
C20
.1
R38
220K
R43
15
5TH
VIDEO AMPL
V6A
(1/2)829-B
R42
10
R44
10
R45
10
+250V D-C
R47
470
R48
390
C22
75
5TH
VIDEO AMPL
V6B
(1/2)829-B
R46
10
R52
10
REFLECTOR
CAP
C25
.1
R51
800
L3
C23
.1
C24
4
+300V D-C
MODULATOR
OUTPUT TO
VTVM
R49
220
R50
100
J4
TM689-88

NOTE:
UNLESS OTHERWISE SHOWN
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UF

Figure 151. Second feedback-amplifier section, V3 and V6, simplified schematic diagram.

(*a*) *Third video amplifier V3.* The output of V2B is coupled through capacitor C12 to the grid of V3, a 6AG7 pentode. Resistor R25 is the grid load resistor. The amplified signal appears across plate load resistor R27. The network of R26 and C13 in the plate circuit provides low-frequency compensation to improve the response of the amplifier. Cathode bias and degenerative feedback are developed across resistor R43, which acts as a common cathode resistor for both V3 and V6. The feedback circuit is described in (*d*) below. Screen-grid potential is obtained directly from the +150-volt line. Capacitors C15 and C16 act as the screen-voltage video bypass capacitors; similarly, C14 is the bypass capacitor for the plate. Capacitors C27 and C28 are heater bypass capacitors.

(*b*) *Fourth video amplifier, V4 and V5.*

1. The fourth video amplifier uses two type 6AG7 pentodes in parallel. The output of V3 is coupled through capacitor C17 to the grids of V4 and V5. Resistors R29 and R30 in the grid circuits are parasitic suppressors. Fixed grid bias is provided from the —150-volt line through the voltage-divider network of R37, R39, R41, and R40. Resistor R28 is the grid load resistor. The signal applied to the grids is amplified in both tubes in parallel and appears across plate load resistor R34. Resistors R32 and R33 in the plate circuits are parasitic suppressors.

2. Screen voltage for V4 and V5 is obtained from the +150-volt supply through resistor R31. Resistor R35 and capacitor C19, and R36 and C18 are decoupling networks for the screen-grid circuits.

(*c*) *Fifth video amplifier V6.*

1. The fifth video amplifier uses an 829B twin tetrode with both sections connected in parallel. The output developed across plate load resistor R34 of the fourth video amplifier is coupled to the grids of V6A and V6B through coupling capacitor C20. Resistors R42 and R44 in the grid circuits are parasitic suppressors. Fixed grid bias is obtained from the —150-volt line through the voltage-divider network of R37, R39, R40, and R41. Resistor R38 is the grid load resistor. Capacitor C21 is a video bypass capacitor preventing feedback of video signal to the grids of the fourth video amplifier, which also is connected to the —150-volt line through the same grid bias voltage-divider network.

2. A plate load consisting of resistor R51 and peaking coil L3 is used for both pentode sections of V6 in parallel. This network improves the high-frequency response of the amplifier. The peaking coil is adjusted to provide the same modulator gain at 4.5 mc as at 100 kc. This permits a fairly flat response over a very wide frequency band. Resistors R45 and R46 in the plate circuits are parasitic suppressors. Cathode bias is provided by R43, which also provides feedback voltage to V3. The screen grids are connected to the +250-volt line through voltage-dropping resistors R47 and R48. Video bypassing for the screen grids is provided by C22.

(*d*) *Feedback circuit.* Cathode resistor R43 is common to both V3 and V6. With this arrangement, a portion of the video signal from the fifth video amplifier is fed back to the third video amplifier. This feedback voltage is degenerative and stabilizes the overall voltage gain of the feedback-amplifier section.

(4) *Protection diode and output circuit* (fig. 152). The output of the fifth video amplifier is applied to the reflector electrode of the klystron

through parasitic suppressor resistor R52, coupling capacitor C25, and wire W4. Protection diode V7, a 6X4W, is connected across the klystron and is located on the modulator subchassis, but is functionally a part of the oscillator circuit.

(5) *General metering facilities.* Provision is made in the modulator for metering various voltages. Receptacle J3, MOD INPUT to VTVM (fig. 149), and receptacle J4, MOD OUT TO VTVM (fig. 151), are provided for connecting the appropriate cable assemblies from the vtvm portion of the radio transmitter. The input video signal voltage across R1 and R2 in the modulator input circuit is connected directly to J3. The video output voltage in the cathode circuit of V6 is fed to J4 through voltage divider R49 and R50. Resistors R54, R55, and R56 in the modulator (fig. 152) are used for klystron reflector voltage metering. Resistor R23 is a metering resistor for the beam voltage.

165. Rf Generator

a. General. The rf generator consists of a klystron oscillator and a power amplifier stage feeding the antenna system. In this circuit, an attenuating cable, a double coupler, a 2-slug tuner, and a triple coupler are used, and a wavemeter is provided for frequency measurement. The klystron oscillator is capable of being frequency modulated in a video-frequency range of 30 cps to about 6 mc, at deviations of as much as ±4.5 mc. The klystron oscillator output is 5 to 10 watts of fm microwave energy. This output is attenuated about 6 db in an attenuating cable to isolate the klystron from amplifier load variations; it is sent through a double coupler, where two metering signals are tapped off, then passes through a 2-slug tuner, which provides an impedance match to the input of the power amplifier. The power amplifier restores the power loss of 6 db and also acts as a buffer between the klystron and the antenna system. The rf generator output, therefore, delivers a microwave signal to the antenna at a power level of 5 to 10 watts. The generator output is fed to the antenna system through a triple coupler, which also provides rf signals to afc circuit, —65 db monitor signal, and meter circuit.

b. Block Diagram Description (fig. 153).

(1) *Klystron oscillator V38.* The modulator video output is applied, through coupling capacitor C25, to the reflector of klystron V38. The reflex-type klys-

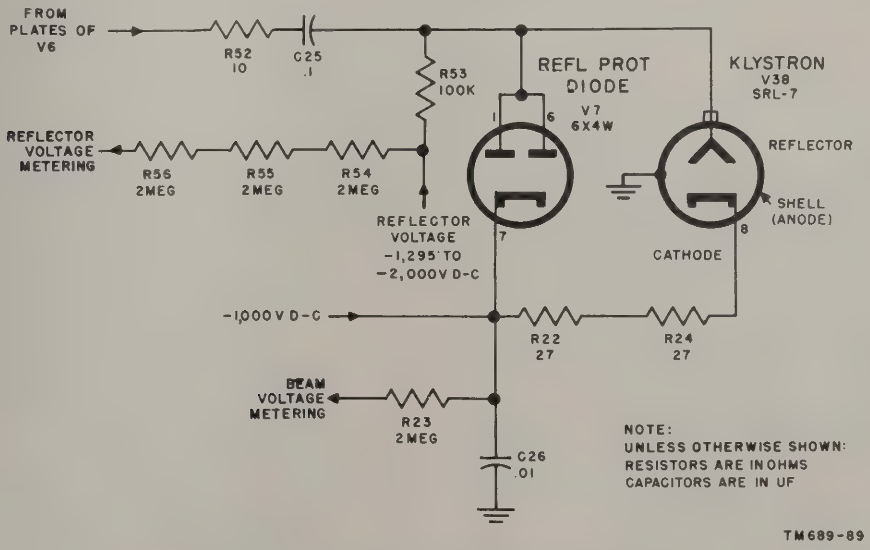
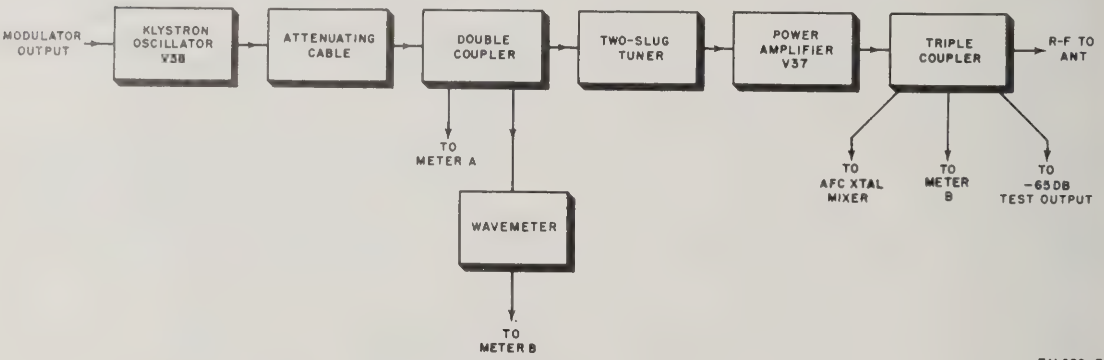

FROM PLATES OF V6
R52 10
C25 .1
R53 100K
REFL PROT DIODE
V7 6X4W
1
6
KLYSTRON V38 SRL-7
REFLECTOR
REFLECTOR VOLTAGE METERING
R56 2MEG
R55 2MEG
R54 2MEG
SHELL (ANODE)
REFLECTOR VOLTAGE -1,295 TO -2,000V D-C
7
8
CATHODE
-1,000V D-C
R22 27
R24 27
BEAM VOLTAGE METERING
R23 2MEG
C26 .01
NOTE: UNLESS OTHERWISE SHOWN: RESISTORS ARE IN OHMS CAPACITORS ARE IN UF
TM689-89

Figure 152. Protection diode V7 and output circuit, simplified schematic diagram.

tron is a type SRL–7. The frequency of oscillation of the klystron depends on the size of the reflex cavity and the dc reflector voltage. The cavity size is controlled by adjusting three tuning screws. Application of the modulating voltage to the reflector causes corresponding variations in the oscillating frequency of the tube. Thus, the fm output is produced.

(2) *Attenuating cable.* The klystron output is coupled by a probe in the cavity, through a connector, to a length of type RG–21A/U attenuating cable. The length of the cable in this application is selected to attenuate the rf signal approximately 6 db from its input level, which isolates the klystron from load variations that would adversely affect its stability.



TM 689-71

Figure 153. Rf generator, block diagram.

(3) *Double coupler.* The signal then is passed through a double coupler, which passes the main signal on to the 2-slug tuner, and extracts a small portion of the signal from the main signal path for measuring purposes. The double coupler provides two such outputs: one, a dc output from a crystal rectifier contained in the coupler, to operate power METER A, and the other, an rf output, is used to feed a wavemeter to measure the operating frequency of the klystron.

(4) *Wavemeter.* The wavemeter contains a resonant cavity, which is tunable by a plunger over the entire frequency range. The plunger is tuned for maximum metered current from the built-in crystal, a dial reading is taken and, from a calibration chart, the frequency of operation is determined.

(5) *Two-slug tuner.* The main double-coupler output is passed through a 2-slug tuner, the main function of which is to match the impedance of the klystron output and attenuating cable to that of the power amplifier input.

(6) *Power amplifier V37.* The rf energy from the 2-slug tuner is fed to the power amplifier, which amplifies the signal and isolates the klystron from the effects of antenna load variations. Power amplifier V37, a 2C39A lighthouse triode, is mounted in a dual folded coaxial-line cavity. One cavity forms the grid-cathode circuit; the other forms the grid-plate circuit. Each is tuned to the desired frequency by adjustable plungers. The input signal is probe-coupled to the grid-cathode cavity and the output is obtained by another probe from the grid-plate cavity. The power amplifier output power of 5 to 10 watts then is coupled to the triple coupler.

(7) *Triple coupler.* The triple coupler has three decoupled outputs instead of two. The main output is fed to the duplexer and then to the antenna, or directly to the antenna. One decoupled output

is used to furnish a monitoring signal to the afc crystal mixer. Another of the decoupled outputs is made accessible for testing at the rear of the transmitter cabinet and is between 65 and 71 db down from the full power-output level. The third decoupled output is detected by a crystal rectifier in the coupler and is fed to the meter panel, where it is used to measure the output of the power amplifier.

c. *Detailed Circuit Description.*

(1) *Klystron oscillator V38 and protection diode circuit* (figs. 152 and 154).

(*a*) *Schematic description.*

1. A reflex klystron is used to generate rf energy. For the basic theory of reflex klystrons, refer to TM 11-673. In the text that follows, it is assumed that the reader is familiar with this theory.

2. Reflex klystron V38, a type SRL–7, is operated with its cathode connected to the —1,000-volt regulated beam-voltage supply and its cavity (or anode) grounded. The voltage applied to the reflector electrode includes a dc component, adjusted between —1,300 and —2,000 volts by the REFL VOLTS ADJUST potentiometer connected to the output of the electronic voltage regulator subchassis of the radio transmitter (par. 170), and a video component obtained at the output of the modulator and coupled to the klystron through C25. The klystron dc reflector voltage from terminal 15 of TB5 is applied to the klystron through resistor R53 and wire W4.

3. The anode of the klystron is the shell, which is grounded. The cathode is operated at —1,000 volts, providing the cathode-to-anode, or beam voltage. This beam voltage is applied to the klystron cathode through resistors R22 and R24. Normally, the reflector electrode of the klystron is operated at a voltage more negative than that of the cathode. The reflector electrode of the klystron would be damaged by the

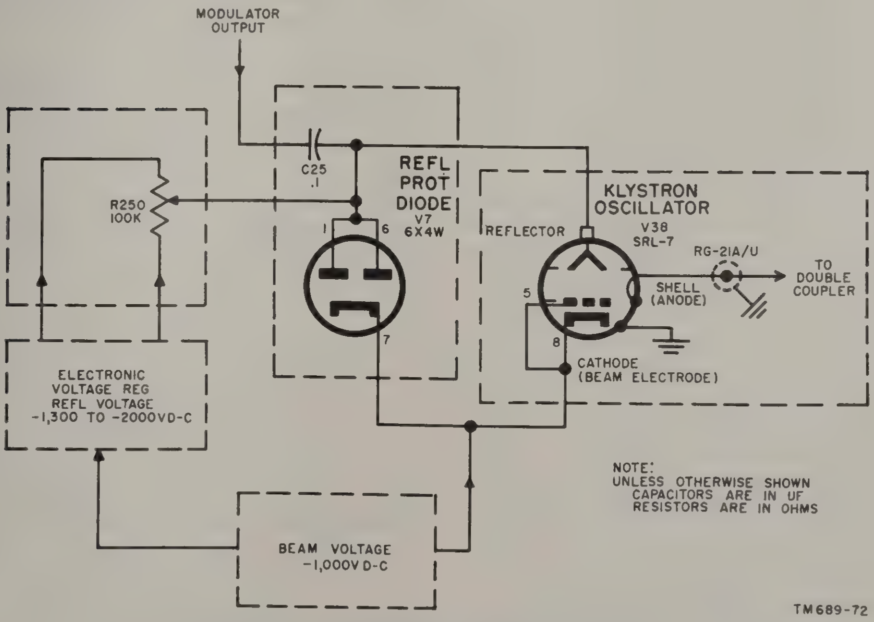

MODULATOR OUTPUT
C25 .1
REFL PROT DIODE V7 6X4W
1
6
7
R250 100K
ELECTRONIC VOLTAGE REG REFL VOLTAGE -1,300 TO -2000VD-C
KLYSTRON OSCILLATOR
V38 SRL-7
REFLECTOR
RG-21A/U
TO DOUBLE COUPLER
SHELL (ANODE)
5
8
CATHODE (BEAM ELECTRODE)
BEAM VOLTAGE -1,000V D-C
NOTE: UNLESS OTHERWISE SHOWN CAPACITORS ARE IN UF RESISTORS ARE IN OHMS
TM689-72

Figure 154. Klystron oscillator circuit V38, simplified diagram.

large current that would flow if the reflector became positive with respect to the beam supply. A component failure, such as C25 shorting, might cause this. To prevent this from happening, a short-circuiting diode type 6X4W, V7, is connected between the reflector and the cathode circuit, at the junction of R22 and the cathode voltage lead. The diode plate is connected to the klystron reflector. Capacitor C26 is used for decoupling.

4. Under normal conditions, the plate of V7 is negative with respect to its cathode; consequently, V7 acts as an open circuit. However, should the klystron reflector electrode become more positive than the cathode, V7 would conduct and effectively place the reflector at the same potential as the cathode, which prevents damage to the klystron.
5. The cavity is resonated over the frequency range of the klystron by three tuning screws that vary the spacing between the cavity plates. Rf energy developed within the cavity is picked up by a probe and fed through a type N female connector and a length of RG–21A/U cable to the double coupler.

(b) *Types of klystron used.* The 1,700- to 2,400-mc frequency range of the transmitter is covered by using one of three reflex klystron types. Each of these klystrons covers a specific portion of the required tuning range. Reflex klystron type SRL–7F covers the low band of 1,700 to 1,930 mc; type SRL–7G covers the middle band of 1,930 to 2,160 mc; and type SRL–7H covers the high band of 2,160 to 2,400 mc. Only one klystron type is requisitioned for use with a given transmitter. This type is selected to permit operation on the assigned channel frequency for that particular radio set.

(c) *Factors affecting klystron tuning.* A relatively intricate procedure is used to tune the klystron to the proper carrier frequency (par. 77). The tuning procedure is described briefly in *1* through *9* below.

1. The klystron is tuned by adjusting REFL VOLTS ADJUST potentiometer R250 on the transmitter chassis and the three cavity tuning screws, to provide maximum power output and linear frequency deviation over the range of the modulating (video) voltage. Consider first the effect of the reflector voltage on the klystron power output. This is shown by curve A in figure 155, in which the power output versus reflector voltage of the klystron is plotted for a fixed setting of the cavity tuning screws. As indicated in this curve, the power output is maximum for a specific value of reflector voltage.
2. For a given setting of the cavity tuning screws, one reflector voltage gives the desired frequency. For other settings, different re-

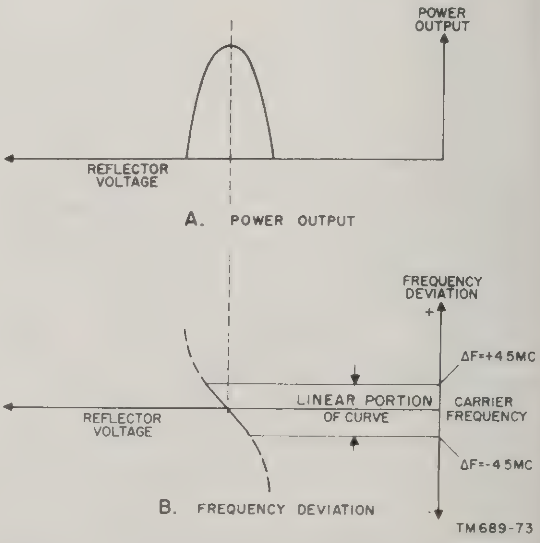


Figure 155. Klystron power output and frequency-deviation curves.

flector voltages are required to give the same frequency. There is only one best combination of the two, however, which results in maximum power output at the desired frequency. The klystron is tuned to the desired carrier frequency by a series of trial-and-error steps consisting of the following:

(a) The video amplifier input is grounded and the REFL VOLTS ADJUST control adjusted for maximum power output.

(b) The frequency of the klystron is measured with the wavemeter ((4) below).

(c) If the frequency is not the one desired, the tuning screws are adjusted in the direction that brings the klystron frequency closer to the desired value. Procedures in (a), (b), and (c) above are repeated until the desired frequency is obtained. This results in the optimum combination of reflector voltage and cavity tuning, which gives maximum power output at the desired frequency.

3. A change in reflector voltage varies the frequency of the klystron. This frequency variation is illustrated by curve B on figure 155, which plots frequency deviation versus reflector voltage. As indicated on this figure, the frequency-deviation curve is fairly linear over a range of ±4.5 mc from the carrier frequency. The carrier frequency is at the center of the linear portion of the curve.

4. The voltage applied to the reflector contains a dc component, adjusted by the REFL VOLTS ADJUST control, as well as the modulating voltage. The REFL VOLTS ADJUST control adjusts the klystron to the carrier frequency; the modulating voltage varies the frequency of the klystron from its carrier frequency to provide an fm signal.

5. To minimize distortion of the modulating signal, it is necesary to operate over the linear portion of the frequency-deviation curve. Be sure that the carrier frequency is at the center of the linear range and that the modulation voltage (as adjusted by the VIDEO LEVEL control in the modulator) does not cause a peak deviation of more than ±3.6 mc.

6. Adjustment of the REFL VOLTS ADJUST control for maximum klystron output places the carrier frequency very close to the proper operating point. Figure 155 shows that the power-output curve is relatively flat around the maximum point so that the REFL VOLTS ADJUST control cannot be set at the proper operating point by observing the klystron power output alone. In fact, the REFL VOLTS ADJUST control may be varied considerably around the maximum power point without appreciably changing the klystron power-output meter reading. Consequently, to adjust the REFL VOLTS ADJUST control to the proper setting, an additional measurement procedure is required. This procedure is indicated in *8* below.

7. Figure 156 shows the frequency-deviation curves when a sawtooth modulation signal is applied to the reflector. Two sets of curves are shown, a solid line and a dotted line. The solid line curves illustrate the proper operating conditions. For example, the dc reflector voltage is set to the proper value and, therefore, the carrier frequency is at the center of the linear frequency-deviation range. The dotted line curves illustrate the effect on the klystron frequency deviation when the dc reflector voltage is not at the proper value. For the incorrect setting, the peak modulation voltage falls in the knee of the frequency-deviation curve, causing a relatively greater positive frequency deviation. As a result, the total frequency deviation of the dotted curve is about 12 mc, while that of the solid curve is 9.0 mc.

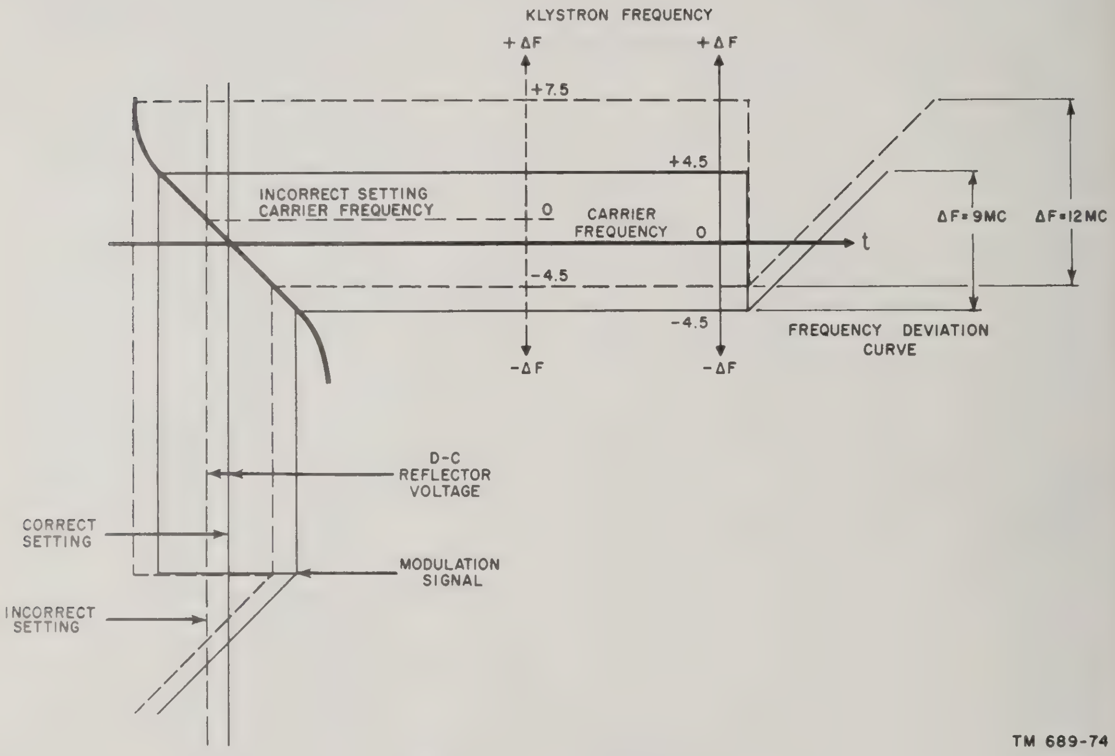

KLYSTRON FREQUENCY
+ΔF
+ΔF
+7.5
+4.5
INCORRECT SETTING
CARRIER FREQUENCY
0
CARRIER
FREQUENCY
0
t
-4.5
-4.5
-ΔF
-ΔF
ΔF=9MC
ΔF=12MC
FREQUENCY DEVIATION
CURVE
D-C
REFLECTOR
VOLTAGE
CORRECT
SETTING
MODULATION
SIGNAL
INCORRECT
SETTING
TM 689-74

Figure 156. Fm signal curve.

8. This illustrates an important characteristic of the reflex klystron oscillator: for a suitable modulating signal, a 9.0-mc symmetrical overall deviation is obtained only when the dc reflector voltage is adjusted to the proper value. For any other value of dc reflector voltage, the total deviation is a symmetrical and greater than 9.0 mc. The procedure for adjusting the REFL VOLTS ADJUST control to the proper operating point is as follows:

(a) Apply a modulating voltage to the klystron sufficient to deviate it over the full linear range of its frequency-deviation curve. This is measured on the percent modulation scale on the PEAK VTVM meter (par. 169).

(b) Adjust the REFL VOLTS ADJUST control for minimum frequency deviation. This may result in a slight decrease in power output, because the point of minimum deviation sensitivity does not always coincide with the point of maximum power output.

9. All pertinent characteristics of the klystron are affected to a great degree by the match or mismatch presented by the rf load. To prevent variations in antenna load impedance from affecting klystron operation, the klystron output is isolated from the antenna by a 6-db attenuating cable, a 2-slug tuner (both used mainly for impedance matching and level adjusting purposes), and a power amplifier. These elements are described in the following subparagraphs. The important parts and adjustments on the klystron are shown on figure 157.

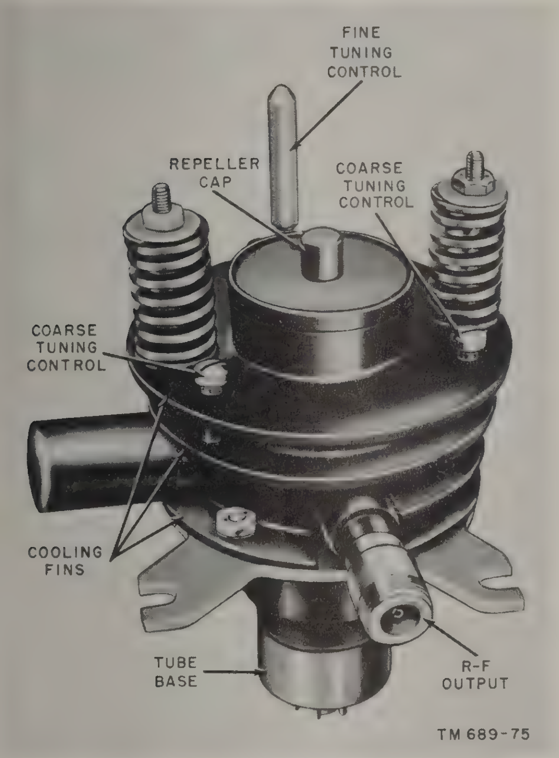


Figure 157. SRL–7 klystron tube.

(2) *Attenuating cable.* The microwave output of the klystron feeds into a length of RG–21A/U cable about 9 feet long, which attenuates the signal approximately 6 db. The attenuation-versus-frequency characteristics of this type of cable is shown on figure 158. As seen on this figure, the cable actually has an attenuation of 6.0 db only at 2.075 mc, with an attenuation of 5.45 db at 1,700 mc and 6.5 db at 2,400 mc.

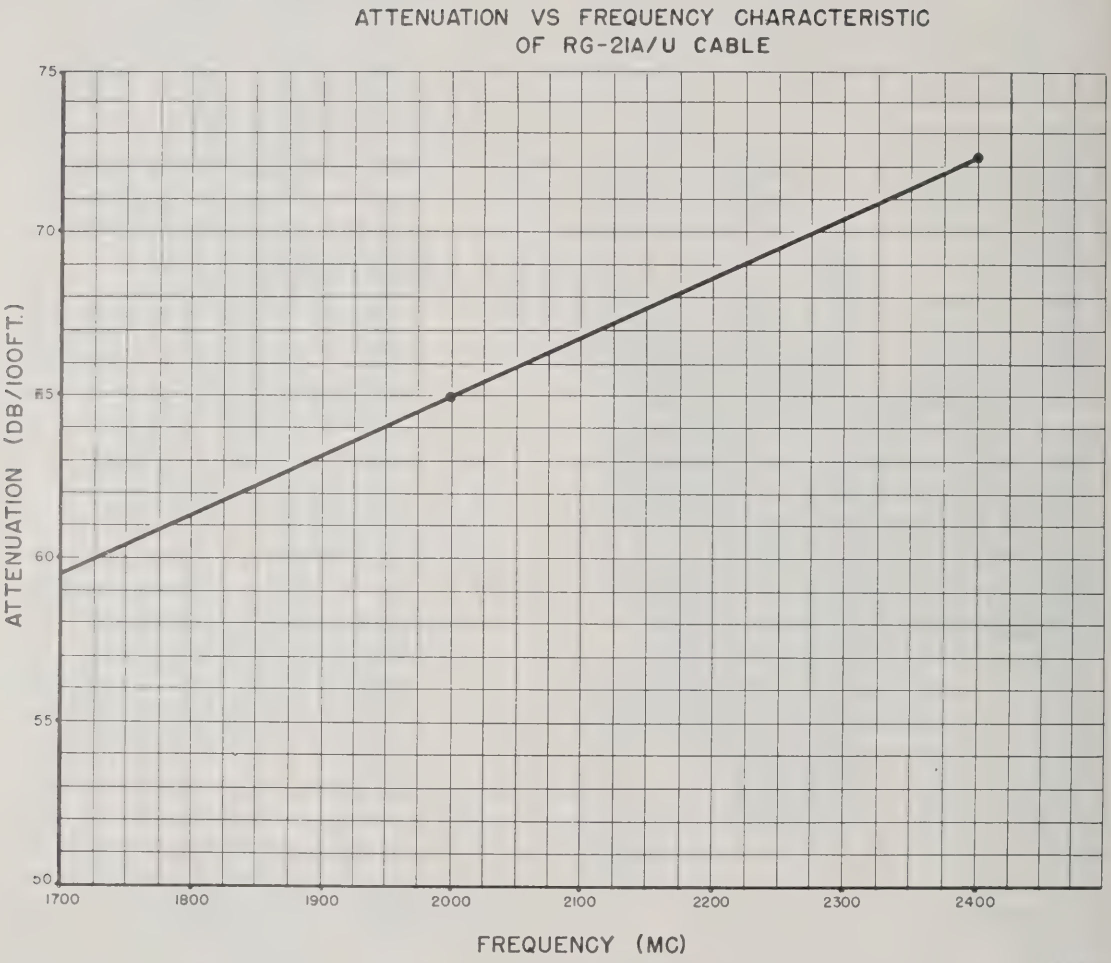
(3) *Double coupler.*

(*a*) The attenuator-cable output feeds a double coupler, which has two decoupled outputs in addition to the main output, which is fed to the 2-slug tuner. The first comes out of the coupler as a dc signal and is fed to the meter panel to give an indication of the rf output of the klystron. The second decoupled output is an rf signal, which is applied to the wavemeter for carrier frequency measurement. The main signal output of the double coupler is fed to the 2-slug tuner.

Note. For Radio Transmitter T–303/G on Order No. 1640–Phila–51 (serial No. 16–297) and Order No. 15739–Phila–55 (serial No. 298–417), the coupling loops of the double coupler have been reduced in diameter to permit adjustment of the loops. This adjustment permits setting of the rf power level to center the reading on the dc meters used in this circuit. Two setscrews also have been added to lock the coupling loops when the adjustment has been made.

(*b*) A simplified electromechanical view of the double coupler is shown on figure 159. Coupling into the transmission line is effected by inserting a loop formed by a 100-ohm resistor and its end leads into the transmission line. One end of the resistor is grounded; the other end is soldered to the inner conductor of the output connector. Both the dc and rf output connections are made in this manner. The dc output differs from the rf output in that it has a 1N21B crystal (CR3) and a bypass capacitor built into the fitting housing of the resistor loop. These serve to detect the rf signal. Resistor R251 isolates the rf signal from the output circuit.

(4) *Wavemeter.* The rf output of the double coupler feeds the wavemeter, which measures the transmitter frequency. It is a silver-plated reentrant-type cavity, tuned to resonance by in-



TM 689-76

Figure 158. Attenuation-versus-frequency characteristics of type RG–21A/U cable.

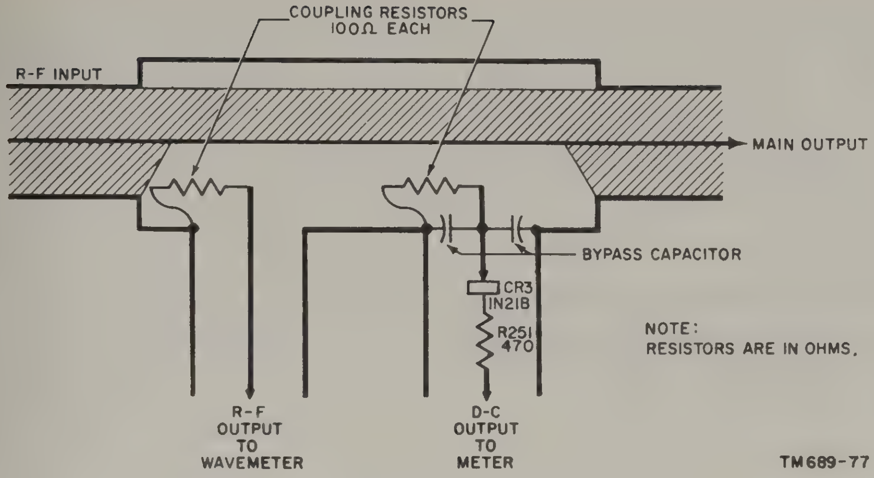

COUPLING RESISTORS
100Ω EACH
R-F INPUT
MAIN OUTPUT
BYPASS CAPACITOR
CR3
1N21B
R251
470
NOTE:
RESISTORS ARE IN OHMS.
R-F OUTPUT TO WAVEMETER
D-C OUTPUT TO METER
TM689-77

Figure 159. Double coupler, simplified diagram.

serting a micrometer head into the reentrant portion of the cavity. A simplified diagram of this unit is shown on figure 160. The microwave energy is fed to the cavity through an rf loop. Another loop picks up the energy and detects it through a crystal rectifier, the output of which is read on a meter. The transmission loss in the cavity is very high for all frequencies other than those near the resonant frequency; thus, for frequencies that are considerably off resonance, no energy will be picked up by the crystal loop. Near resonance, the transmission loss is low and crystal current increases. Maximum crystal current is obtained at the resonant frequency. The wavemeter is tunable over the complete frequency range of the equipment. The wavemeter tuning knob is calibrated in arbitrary numbers. Each wavemeter scale is individually factory-calibrated, and a chart plotting knob setting against actual frequency is furnished for each unit. This calibration chart is mounted on the inner surface of the transmitter cabinet door.

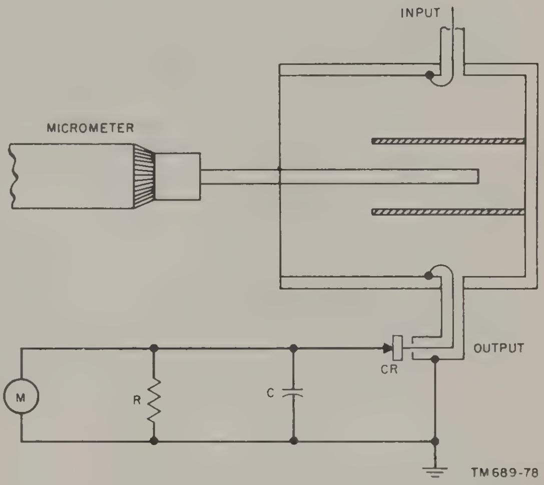

INPUT
MICROMETER
OUTPUT
CR
M
R
C
TM689-78

Figure 160. Wavemeter, simplified diagram.

(5) *Two-slug tuner.* The output of the double coupler feeds into a 2-slug tuner. This unit, together with the attenuating cable, provides isolation, coupling, and impedance matching between the klystron oscillator output and the power amplifier input. As shown on figure 161, the 2-slug tuner is a length of air line constructed so that it has two sleeves, or slubs, of dielectric mounted between the inner and outer lines. These sleeves can be moved along the line independently of each other. By adjusting the position of these slugs, it is possible to match the 50-ohm line from the double coupler to the power amplifier input, the impedance of which varies for different frequencies. The two slugs are ad-

justed to obtain maximum power output.

(6) *Power amplifier V37.*

(a) The output of the 2-slug tuner is fed to the power amplifier stage, V37, which is a type 2C39A lighthouse triode. The power amplifier serves as a buffer between the klystron and the antenna. To prevent overdriving the amplifier, a 6-db loss is required in the attenuating cable and the power delivered to the antenna is about the same as that delivered by the klystron to the attenuating cable.

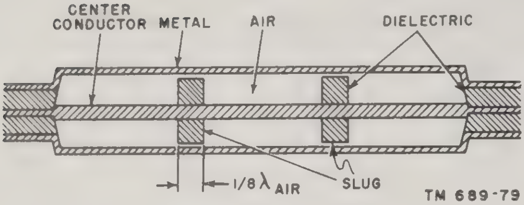
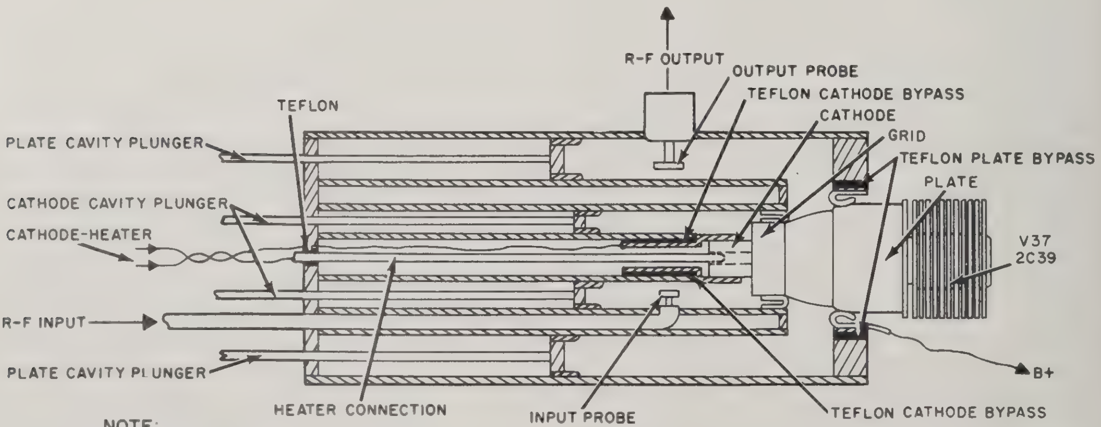

CENTER CONDUCTOR
METAL
AIR
DIELECTRIC
1/8 λ AIR
SLUG
TM 689-79

Figure 161. Two-slug tuner, cross-sectional view.

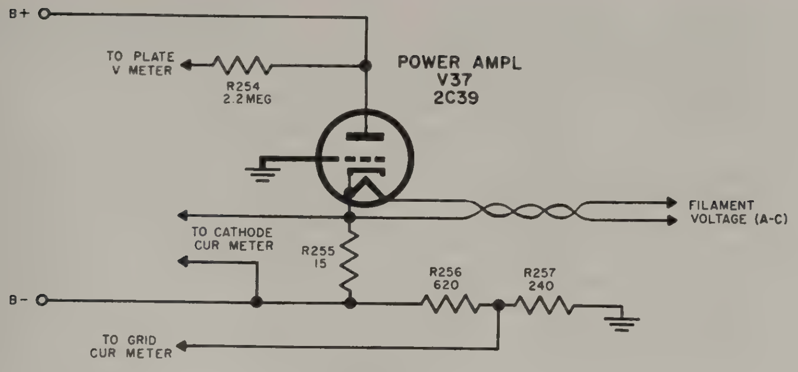
(*b*) The 2C39A lighthouse tube has two folded coaxial-line cavities, each electrically tuned to approximately 3/4 wavelength at the transmitter frequency (fig. 162). One cavity forms the cathode-grid circuit; the other forms the grid-plate circuit. Rf excitation is applied to the cathode-grid input circuit, and output is taken from the plate-grid circuit by a probe. Thus, this stage is equivalent to a grid-separation or grounded-grid amplifier. Cavities such as these can be made to resonate by tuning to any odd multiple of 1/4 wavelength at the operating frequency. These cavities are tuned to resonance at 3/4 wavelength; this value is chosen because of the physical parameters involved.

(*c*) Figure 163 shows the equivalent dc and rf circuits. The input rf power is fed to the circuit by a coaxial line with a center conductor, which extends into the grid-cathode cavity. Rf power delivered to this cavity then is amplified by the tube and appears in the plate-grid cavity. Although a common grid plane is used, there is no direct rf coupling between the grid-cathode and grid-plate cavities. At microwave frequencies, because of *skin* effect, current flows only near the surface of a conductor. Consequently, cathode-grid current flows only on the *inner surface* of the folded grid plane;

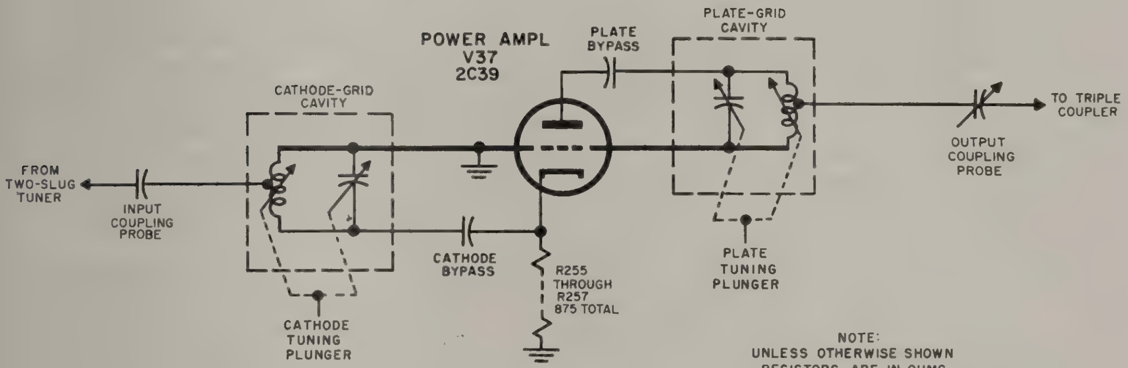

R-F OUTPUT
OUTPUT PROBE
TEFLON CATHODE BYPASS
CATHODE
GRID
TEFLON PLATE BYPASS
PLATE
TEFLON
PLATE CAVITY PLUNGER
CATHODE CAVITY PLUNGER
CATHODE-HEATER
V37
2C39
R-F INPUT
PLATE CAVITY PLUNGER
B+
HEATER CONNECTION
INPUT PROBE
TEFLON CATHODE BYPASS
TM 689-80

NOTE:
DO NOT ATTEMPT TO
DISASSEMBLE AMPLIFIER
CAVITY IN THE FIELD

Figure 162. Power amplifier, cross-sectional view.


B+
TO PLATE V METER
R254 2.2 MEG
POWER AMPL V37 2C39
FILAMENT VOLTAGE (A-C)
TO CATHODE CUR METER
R255 15
R256 620
R257 240
B-
TO GRID CUR METER

A. D-C CIRCUIT


POWER AMPL V37 2C39
PLATE BYPASS
PLATE-GRID CAVITY
CATHODE-GRID CAVITY
TO TRIPLE COUPLER
OUTPUT COUPLING PROBE
FROM TWO-SLUG TUNER
INPUT COUPLING PROBE
CATHODE BYPASS
R255 THROUGH R257 875 TOTAL
PLATE TUNING PLUNGER
CATHODE TUNING PLUNGER
NOTE: UNLESS OTHERWISE SHOWN RESISTORS ARE IN OHMS.

B. R-F CIRCUIT

TM689-81

Figure 163. Power amplifier V37, equivalent dc and rf circuits.

plate-grid current flows only on the *outer surface* of the grid plane (fig. 162). For further information on operating principles and construction of coaxial-line cavities and circuits, refer to TM 11-673.

(*d*) The rf power developed in the grid-plate cavity is picked up by a probe, which forms the inner conductor of a coaxial line at the output of the cavity. This coaxial line transmits the energy to the triple coupler.

(*e*) In the dc circuit diagram of this stage, B— is returned to the junction of cathode resistor R255 and good resistor R256. Resistor R255 supplies self-bias in the event of loss of rf driving power. Operating bias for this stage, however, is provided mainly by the voltage drop across R256 and R257.

(*f*) All electrode contacts are of the spring-finger type (fig. 162). The grid-cathode cavity is formed by two concentric tubes. The cathode bypass capacitor consists of a thin sheet of teflon fitted between the two sections of tubing that make up the cathode line. The grid tube is a double-wall arrangement, permitting the insertion of the input probe between the walls. The input probe terminates in a capacitive disk, which extends into the grid-cathode cavity.

(*g*) The plate-grid cavity is formed by the outer wall of the double-walled grid plane and the outermost tube. The plate bypass capacitor is a sheet of fused-type teflon, wrapped around the anode contact retaining ring. Both the plate-grid and cathode-grid cavities are tuned by sliding, finger-contact plungers that vary the length and resonant frequency of the cavity. The plungers are driven by a gearing arrangement external to the amplifier proper and are controlled manually by two axially mounted annular rings. One ring is for the cathode plunger, the other for the plate plunger. The output probe is a capacitive-disk type, which is adjustable in the cavity both radially and longitudinally.

(7) *Triple coupler.* The output of the power amplifier is fed to the triple coupler through a short length of RG–9B/U cable. This coupler is similar to the double coupler described in (3), above, and shown in figure 159, except that it has three decoupled outputs instead of two. The main output of the triple coupler is fed through an RG–9B/U cable to the rf output connector at the rear of the transmitter. Two of the decoupled outputs are rf signals; the third is a dc signal. The first decoupled output is an rf signal 36 db below the power output level. It is used to feed the crystal mixer in the afc system (par. 166). This is one of the most important signal points in the transmitter, because the signal obtained here is used for comparison with a reference frequency in controlling the operation of the afc system which, in turn, is responsible for holding the transmitter frequency properly *on channel.* The second decoupled output is an rf signal approximately 65 db below the power-output level, and is available at the back of the transmitter for test purposes. The third decoupled output is rectified by CR5, and the resultant dc signal is fed through R252 to the meter panel to indicate power amplifier power output.

166. Afc Circuits

a. General. The transmitter afc circuits consist of four major functional sections—a crystal oscillator, multiplier, and mixer; an if. amplifier, limiter, discriminator, and video preamplifier; a chopper and chopper amplifier, together with relay control circuits; and an afc motor drive system. An overall description of these functional circuits is given in *b* below.

b. Block Diagram Description (fig. 164).

(1) A crystal-controlled, vacuum-tube oscillator generates signals at a preset frequency in the range of 68 to 85 mc. This signal is doubled, tripled, and amplified in later stages, and its fourth or fifth harmonic (depending on the frequency selected) is mixed with the rf signal fed from the triple coupler to a crystal mixer. The resulting difference signal is an if. of 120 mc.

(2) The 120-mc if. is fed through a 6-stage, wide-band, if. amplifier, which amplifies and sends it to two limiters connected in cascade. The limiters eliminate any amplitude variations in the signal, set its reference level, and pass it on to a discriminator. The discriminator output includes the video modulation information and the 6-mc order-wire subcarrier. Part of the discriminator output is fed, as a dc signal, to the chopper amplifier input, to the meter panel for the afc correction-signal monitoring, and to the TRANSFER CONTROL connector in the order-wire transmitter, where it is made available to the transfer control equipment. The remainder of the signal, containing the video and order-wire carrier intelligence, is amplified further by a video preamplifier, fed through a cathode-follower stage, and sent to the vtvm and order-wire monitor subchassis, where it is used for further measuring and monitoring purposes.

(3) The portion of the signal sent to the chopper amplifier input is converted by the chopper into a series of short rectangular pulses, the amplitude of which is directly proportional to the amount of frequency error. The polarity is opposite to that of the dc signal. These pulses are amplified in the chopper amplifiers and phase inverter, which couples both positive and negative pulses to a peak detector circuit. The peak detector output governs the operation of a relay control tube which, in turn, effects the closing of one or the other of two relays.

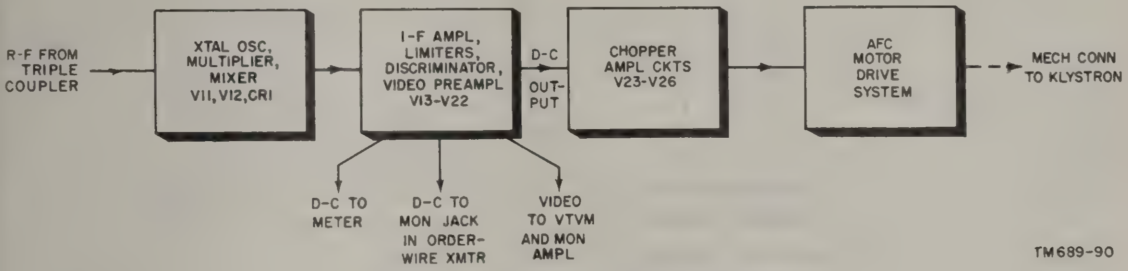

R-F FROM TRIPLE COUPLER
XTAL OSC, MULTIPLIER, MIXER V11, V12, CR1
I-F AMPL, LIMITERS, DISCRIMINATOR, VIDEO PREAMPL V13-V22
D-C OUT-PUT
CHOPPER AMPL CKTS V23-V26
AFC MOTOR DRIVE SYSTEM
MECH CONN TO KLYSTRON
D-C TO METER
D-C TO MON JACK IN ORDER-WIRE XMTR
VIDEO TO VTVM AND MON AMPL
TM689-90

Figure 164. Afc circuit, block diagram.

(4) One of these relays applies power to operate the klystron tuning drive motor clockwise; the other relay applies power to the motor to cause it to rotate counterclockwise. As the motor tunes the klystron so that its output returns to the desired frequency, the afc error signal diminishes, finally reaching the point where the balance condition is satisfied, the relay opens, and the afc motor stops.

(5) Additional block-diagram details of the circuits described above are given in *c*(1)(*a*), (2)(*a*), (3)(*a*), and (4)(*a*), below, covering the detailed operation of each of the major sections of the afc circuits.

c. Detailed Circuit Description.

(*1*) *Crystal oscillator, multiplier, and mixer.*

(*a*) *General* (fig. 165). The crystal oscillator circuit provides a crystal-controlled rf signal, the frequency of which is multiplied and mixed with part of the rf output of the power amplifier to provide a 120-mc if. signal. It consists of crystal oscillator V11A operating at any one of 27 channel frequencies within the frequency range of 68 to 85 mc, frequency doubler V11B, followed by frequency tripler V12, and crystal mixer CR1. The crystal mixer accepts a sample of the transmitter output from the triple coupler and mixes it with the 24th or 30th harmonic of the fundamental crystal oscillator frequency. The resulting

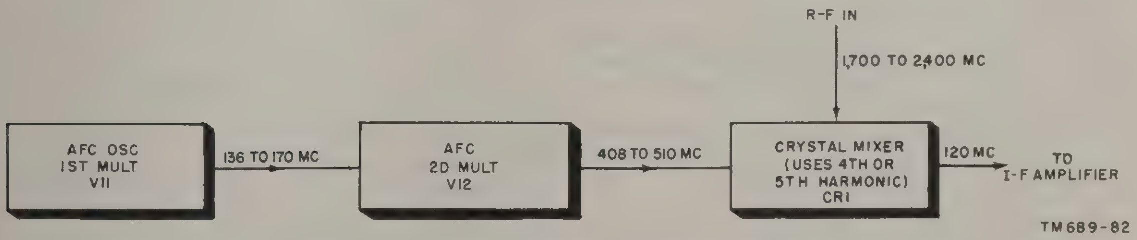

R-F IN
1,700 TO 2,400 MC
AFC OSC 1ST MULT V11
136 TO 170 MC
AFC 2D MULT V12
408 TO 510 MC
CRYSTAL MIXER (USES 4TH OR 5TH HARMONIC) CR1
120 MC
TO I-F AMPLIFIER
TM689-82

Figure 165. Crystal oscillator, multiplexer, and mixer, block diagram.

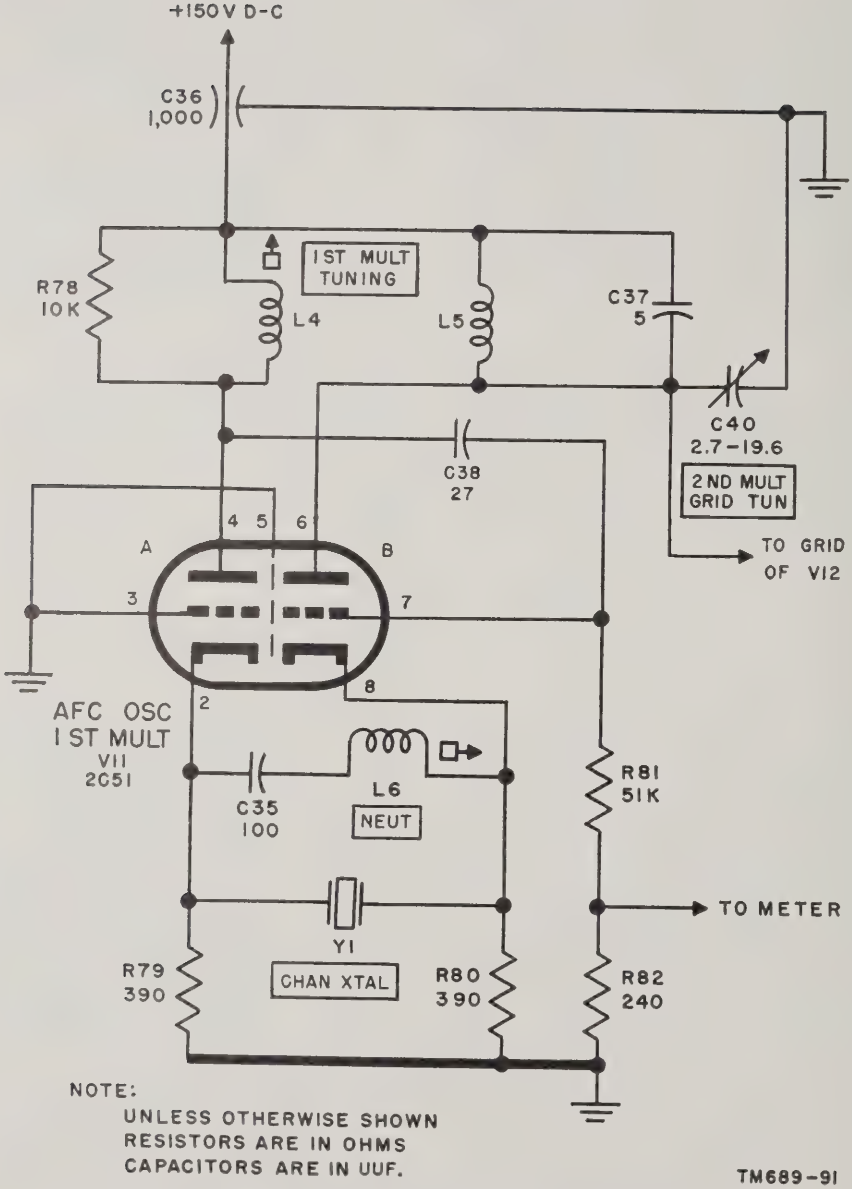

+150V D-C
C36
1,000
1ST MULT TUNING
R78
10K
L4
L5
C37
5
C40
2.7-19.6
2ND MULT GRID TUN
C38
27
TO GRID OF V12
4
5
6
A
B
3
7
8
2
AFC OSC
1 ST MULT
V11
2C51
C35
100
L6
NEUT
R81
51K
TO METER
Y1
CHAN XTAL
R79
390
R80
390
R82
240
NOTE:
UNLESS OTHERWISE SHOWN
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UUF.
TM689-91

Figure 166. Crystal oscillator doubler VII, simplified schematic diagram.

if. signal then is fed to the if. amplifier chassis.

(*b*) *Crystal oscillator doubler V11* (fig. 166).

1. Crystal oscillator V11 is a 2C51 twin triode, and operates in the range of 68 to 85 mc, depending on the crystal used. The oscillator uses a cathode feedback-type circuit, with crystal Y1 connected between the two cathodes of V11. The crystal acts as a low-impedance feedback path at its resonant frequency, and thereby controls the overall frequency stability of the circuit.

2. Tube V11A operates as a grounded-grid amplifier with a broadly tuned plate circuit, consisting of inductor L4 and the distributed capacitance of the inductor. Resistor R78 is placed across this resonant circuit to lower its Q, and to reduce the feedback voltage. This reduces the output somewhat, but increases stability. The rf voltage developed across this resonant circuit is coupled to the grid of V11B through capacitor C38. The voltage developed across cathode resistor R80 of V11B is coupled across the cathode resistor of V11A through crystal Y1. The two cathodes are in phase; consequently, the circuit is regenerative.

3. The quartz crystal provides a low-impedance feedback path exactly at its series-resonant frequency. The overall circuit gain is maximum at this frequency. Cathode-to-cathode impedance is high for all other frequencies in the vicinity of the crystal resonant frequency and the plate-circuit gain is low at frequencies far from the resonant frequency; therefore, oscillation occurs only at the series-resonant frequency of the crystal. Neutralizing coil L6 in series with capacitor C35 is placed across the crystal to resonate out the capacitance of the crystal holder, further insuring that a high series impedance is presented to all frequencies other than the series-resonant frequency of the crystal.

4. Tube V11B also acts as a frequency doubler, with its plate circuit of L5, C37, and C40 tuned to the second harmonic of the crystal frequency. The voltage developed across this resonant circuit is applied to the grid of V12. Resistor R81 is the V11B grid load, and R82 serves primarily as the meter resistor, and C36 serves as the plate bypass capacitor.

(*c*) *Frequency tripler V12* (fig. 167). The output of V11B is coupled through capacitor C41 to the grid of V12, a 5654/6AK5W pentode, connected in a frequency tripler circuit. The plate circuit of this stage is resonated by an adjustable quarter-wave stub physically located within the crystal mixer assembly (A–A^1, fig. 167). This quarter-wave stub is adjusted to resonate with capacitors C45 and C46 and the capacitance of tube V12 at the third harmonic of the grid-input signal frequency. Resistors R86 and R83 are the plate and screen-dropping resistors, respectively. Capacitor C42 is the plate bypass capacitor. Resistor R84 is the grid load, and R85 serves primarily as the meter resistor.

(*d*) *Crystal mixer CR1* (fig. 167).

1. The mixer circuit uses a 1N23B crystal, CR1, and functions as a mixer and harmonic generator. The output of the frequency tripler is coupled directly to CR1, where it is mixed with a sample of the transmitter output frequency obtained through a capacitor built into a *tee* fitting. One of the frequencies created by the *beating together* of the rf signal and a harmonic of the frequency-tripler output is the desired 120-

mc if. There are two possible paths this signal might take. One is into a branch of the tee leading back to the triple coupler. The second is through the branch of the tee leading to the if. amplifier. The capacitor in the rf input line prevents the if. from being short-circuited in the rf circuitry because it presents a relatively high impedance to 120-mc energy trying to travel in the reverse direction, but appears as a low impedance to rf energy traveling in the forward direction. As a result, practically all the 120-mc if. signal is fed through the desired path to its load circuit at the input to the if. amplifier.

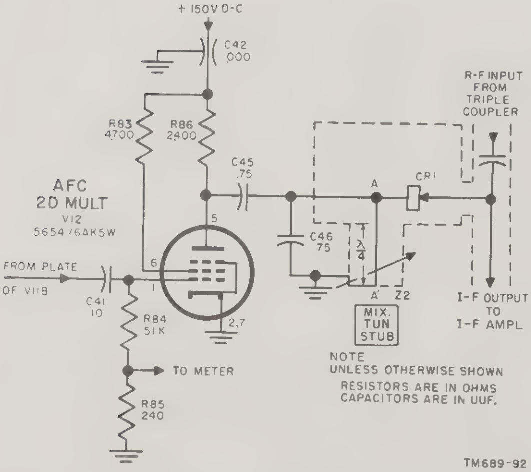


Figure 167. Frequency tripler V12 and crystal mixer CR1, simplified schematic diagram.

2. Many harmonic frequencies are developed across the crystal; however, only the harmonic frequency which is 120 mc above that of the rf input signal is used to beat with the rf signal and produce the 120-mc if. signal which is amplified by the if. amplifier. All other frequencies are rejected in the if. amplifier input circuit. For carrier frequencies below 1,900 mc, the fourth harmonic of the frequency-tripler output is used; for carrier frequencies above 1,900 mc, the fifth harmonic is used.

(2) *If. amplifier, limiter, discriminator, and video preamplifier.*

(*a*) *General* (fig. 168). The if. signal from the crystal mixer in the crystal multiplier subchassis is fed to the if. amplifier. Here the signal is amplified by six stages of if. amplification, then fed through two limiters to a discriminator. The output of the discriminator consists of a dc error signal that is fed to the chopper amplifier, which controls the klystron frequency-correcting motor, and a video signal amplified by a video amplifier and used for monitoring in the vtvm. The six if. amplifier stages are arranged in two triplets, or triple stagger-tuned stages. The first, second, and third if. amplifiers comprise the first triplet. The fourth, fifth, and sixth if. amplifiers make up the second triplet.

(*b*) *Typical if. amplifier circuit.*

1. All six if. amplifier stages are identical circuits with the exception of the sixth if. amplifier, which is modified slightly. Figure 169 is a simplified schematic diagram of the first if. amplifier. Except for the use of different reference symbols for the component parts, this schematic applies equally to any of the other if. amplifiers.

2. In the if. amplifier circuit in figure 169, the if. input signal is applied through coupling capacitor C47 to the grid of V13, a 5654/6AK5W pentode. The signal is amplified and appears across tuned coil L9, which is resonated by its own distributed capacitance at the desired if. Resistor R88 is a grid load, R90 is the cathode-biasing resistor, and R91 iso-

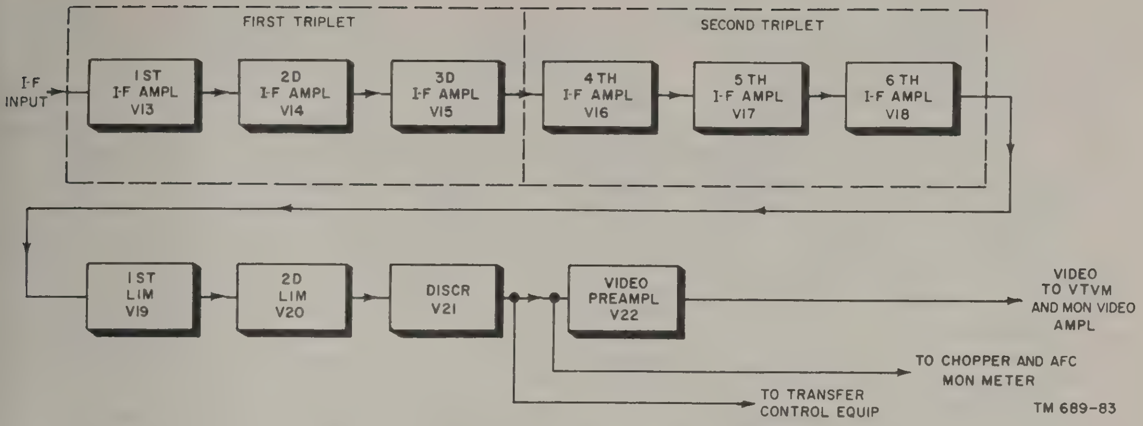

FIRST TRIPLET
SECOND TRIPLET
I-F INPUT
1ST I-F AMPL V13
2D I-F AMPL V14
3D I-F AMPL V15
4TH I-F AMPL V16
5TH I-F AMPL V17
6TH I-F AMPL V18
1ST LIM V19
2D LIM V20
DISCR V21
VIDEO PREAMPL V22
VIDEO TO VTVM AND MON VIDEO AMPL
TO CHOPPER AND AFC MON METER
TO TRANSFER CONTROL EQUIP
TM 689-83

Figure 168. If. amplifier, limiter, discriminator, and preamplifier, block diagram.

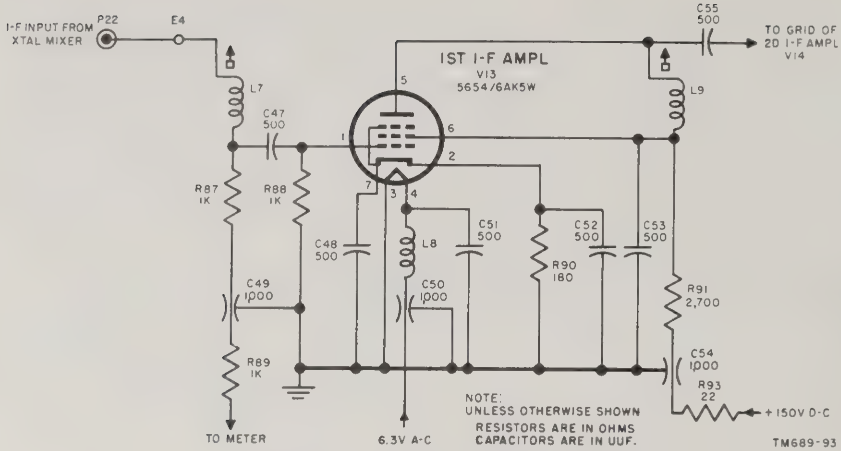
lates the if. from the B+ supply. Resistor R93 provides additional decoupling and voltage dropping. Capacitors C48, C50, C52, C53, and C54 are all if. bypass capacitors. Inductor L8 and capacitor C51 provide decoupling for the filament supply.

(*c*) *First triplet, V13 through V15.*

1. Tubes V13, V14, and V15, the first, second, and third if. amplifiers, are cascade-connected to form a circuit configuration known as a stagger-tuned triplet. A stagger-tuned triplet consists of three cascaded amplifiers with single-tuned coupling networks having Q's and resonant frequencies which yield a high overall gain bandwidth product. Refer to TM 11–667, for a more complete theory discussion. This is accomplished by tuning one stage to the nominal center frequency, one stage somewhat above the frequency, and the third stage somewhat below the center frequency. The result is a relatively flat response over a wide frequency band. To help compensate also for the characteristic drop at the sides of a tuned-circuit curve, the Q's of the stages tuned above and below the center frequency are adjusted to be about twice as high as the Q of the on-frequency stage. This also aids in *squaring* the response curve by giving a sharper dropoff at the sides.

2. In the first triplet, the first if. amplifier is tuned to 130.5 mc, the second amplifier to 120 mc, and the third amplifier to 110.5 mc. This arrangement provides an overall bandwidth of 21 mc and an overall gain of approximately 28 db. The input to this triplet is obtained from the crystal multiplier mixer through coil L7, which is resonated to 120 mc, and effectively rejects any signals appearing at this point with a frequency far from 120 mc. The crystal mixer current is checked by the meter circuit, which is through metering resistors R87 and R89, and the complete dc path through crystal CR1. Capacitor C49 in this circuit is an if. bypass capacitor.

(*d*) *Second triplet, V16 through V18.* Tubes V16, V17, and V18, the fourth, fifth, and sixth if. amplifiers, are cascade-connected to form the second triplet. In this triplet, the fourth if. amplifier is tuned to 130.5 mc, the fifth if. amplifier to



NOTE:
UNLESS OTHERWISE SHOWN
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UUF.

Figure 169. Typical if. amplifier, simplified schematic diagram.

110.5 mc, and the sixth if. amplifier to 120 mc. The sixth if. amplifier is slightly different from the first five if. amplifiers in that the if. voltage is developed across plate-load resistor R112 instead of a coil, and resonance is effected by coil L19 in the input circuit of the next stage.

(*e*) *First limiter V19* (fig. 170).

1. The output of the sixth if. amplifier is coupled through C91 to the first limiter, V19, a 5654/6AK5W pentode. In this limiter, the cathode is grounded and a highly stable +42-volt screen and plate voltage is used. As a result, an essentially constant output level is maintained for both positive and negative half-cycles of the incoming if. signal. The if. amplifier gain is sufficient to raise the if. signal to a level that allows the limiter to be overdriven in both the positive and negative directions. In the positive direction, plate current saturation limiting occurs because of the low plate and screen voltage, and limiting in the negative direction occurs because grid cutoff is reached. Inductor L19 in the input circuit to this stage is resonated at 120 mc. Resistor R116 lowers the Q of the coil L21. Resistor R117 and capacitor C96 keeps the screen voltage constant thereby preventing degeneration. Capacitor C96 is the screen if. bypass capacitor. Resistor R118, with bypass capacitor C97, isolates the +42-volt supply from if. signals.

2. Crystal CR2 detects a portion of the signal and develops a positive voltage across the resistance-capacitance (RC) network comprised of R115 and C93 that is proportional to the amplitude of the incoming signal. This voltage is applied to a meter on the meter panel through resistor R113. It indicates the if. level by measuring the first limiter grid signal. Capacitor C92 in this circuit is the if. bypass capacitor.

(*f*) *Second limiter V20* (fig. 170).

1. Inductors L21, L23, and L22, with associated tube capacitances, comprise a wide-band tuned pi-section, coupling network and couple the voltage developed in the plate circuit of the first limiter through C98 to the grid of second limiter V20, a 5654/6AK-

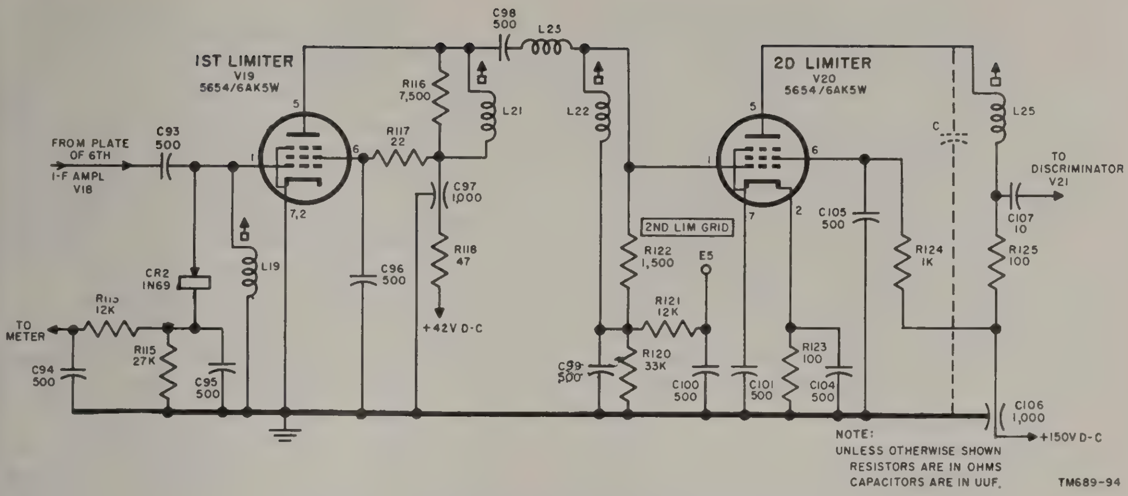

C98
500
L23
1ST LIMITER
V19
5654/6AK5W
R116
7,500
L21
L22
2D LIMITER
V20
5654/6AK5W
L25
FROM PLATE
OF 6TH
I-F AMPL
V18
C93
500
R117
22
C
TO
DISCRIMINATOR
V21
C97
1,000
7,2
2ND LIM GRID
C105
500
C107
10
R118
47
R122
1,500
E5
R124
1K
R125
100
CR2
IN69
L19
C96
500
R113
12K
R121
12K
TO
METER
R115
27K
+42V D-C
R123
100
C94
500
C95
500
C99
500
R120
33K
C100
500
C101
500
C104
500
C106
1,000
+150V D-C
NOTE:
UNLESS OTHERWISE SHOWN
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UUF.
TM689-94

Figure 170. First and second limiters V19 and V20, simplified schematic diagram.

5W pentode. The three legs, mutually resonated, together form the network, which is equivalent in performance and band-pass characteristics to a conventional double-tuned if. transformer. Tube V20 delivers an essentially constant-level output with a varying level input. When an input signal reaches the grid circuit, the signal charges C98 in proportion to signal amplitude. The discharge path for C98 must be through R122 and R120. The values of these components are such that the circuit has a relatively long time constant, effectively establishing a bias level that sets the operating point of the tube in accordance with the input signal level. If the input signal level increases, a larger bias voltage is built up across C98. This changes the effective operating level of the tube, and the output level is maintained fairly constant. Conversely, if the signal level decreases, the bias voltage decreases. A test point, E5, is placed in the circuit so that the band-pass waveform can be displayed on a test scope for if. alinement. It also can be used to check the bias developed. This bias is a measure of limiting action and depends on the modulation level. The test point is connected to the circuit through decoupling circuit R121 and C100.

2. The tuned circuit in the plate of V20 is formed by L25 and the plate-cathode capacitance of V20. This circuit is resonant at 120 mc. The if. voltage developed across R125 in series with L25 is applied then to the discriminator. Capacitors C101, C104, and C105 in this stage are bypass capacitors, resistor R123 is the cathode-biasing resistor, and resistor R124 is the screen-dropping resistor. Resistor R122, shunting L22, provides proper Q for the grid circuit.

(*g*) *Discriminator V21* (fig. 171).

1. The if. voltage developed across R125 in the plate circuit of the second limiter is applied through coupling capacitor C107 to two series-resonant circuits in discriminator stage V21, a 6AL5W dual diode. One circuit, which consists of L27 in series with the plate-cathode capacitance of one-half of the dual diode (C1, fig. 171), is resonant at 141 mc. The other circuit, consisting of L26 in series with the plate-cathode capacitance of the other half of the dual diode (C2, fig. 171), is resonant at 108 mc. Resistors R128 and R126 are used as load resistors for the series-resonant circuits, and form the grid-load impedance of V22A.

2. To understand the action of the discriminator, consider first the voltage variation with frequency (response curve) that would exist (with respect to ground) if the discriminator output were perfectly balanced. The theoretical response curve of each of the two resonant circuits then would be as shown in figure 172. The voltage developed across the 108-mc resonant circuit is negative and the voltage developed across the 131-mc resonant circuit is positive with a respect to the ground reference level. The actual discriminator output is the algebraic sum of these two voltage curves. This is illustrated by the composite broken-line curve on figure 172. For example, at 120 mc, both voltages are equal in magnitude; therefore, the resultant voltage is zero. At 130 mc, a maximum positive voltage is obtained, and at 110 mc, a maximum negative voltage is obtained. Refer to figure 173, which shows a typical measured output voltage versus signal frequency response curve of the discriminator. It is necessary that the cross-over point in the discriminator curve be alined precisely at 120 mc. Any variation from this will cause an equal variation in the rf carrier frequency. The discriminator must always be alined whenever a 6AL5W tube is changed. This is done by field maintenance.

3. In addition to being fed to video preamplifier V22, the discriminator output is sent, as a dc signal, to three other points in the equipment. From the discriminator output, the signal passes through R130, through terminal 5 of TB11 to terminal 8 of TB12 at the input to the chopper. Part of the signal is tapped off at this point and sent through pin L of J12 to indicate the afc correction voltage on METER A in the meter panel. Resistor R129 also takes the signal from the discriminator output and passes it through terminal 2 of TB11, terminal 4 of TB4 to terminal 3 of TB1 on the order-wire transmitter. The signal is not used in the order-wire transmitter, but appears at pin F of J3, which is used for connecting the transfer control equipment.

4. If the klystron center frequency is correct, the signal output at this point is zero. If the klystron frequency is high, a negative dc component is present; if the frequency is low, the dc component is positive. This is indicated on METER A in the meter panel.

(*h*) *Video preamplifier V22* (fig. 174).

1. The output of the discriminator obtained across load resistors R128 and R126 contains the video signal plus the order-wire carrier applied at the input to the modulator. This signal is fed to the grid of V22A, one-half of a 2C51 twin triode, which amplifies it and passes it through cathode follower V22B. Resistor R132 and inductor L29 in the plate circuit of V22 comprise a shunt-peaking circuit, which provides the desired high-frequency response characteristic. Resistor R131 is the cathode-biasing resistor.

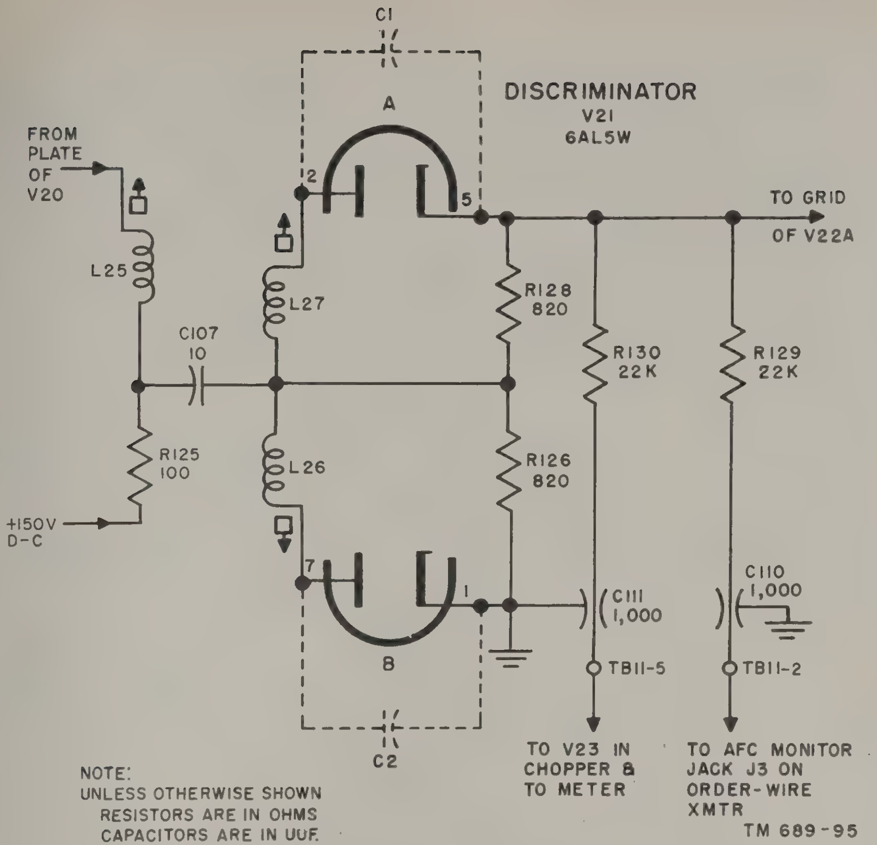

C1
DISCRIMINATOR
V21
6AL5W
A
FROM
PLATE
OF
V20
2
5
TO GRID
OF V22A
L25
L27
R128
820
C107
10
R130
22K
R129
22K
R125
100
L26
R126
820
+150V
D-C
7
1
C111
1,000
C110
1,000
B
TB11-5
TB11-2
C2
TO V23 IN
CHOPPER &
TO METER
TO AFC MONITOR
JACK J3 ON
ORDER-WIRE
XMTR
NOTE:
UNLESS OTHERWISE SHOWN
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UUF.
TM 689-95

Figure 171. Discriminator V21, simplified schematic diagram.

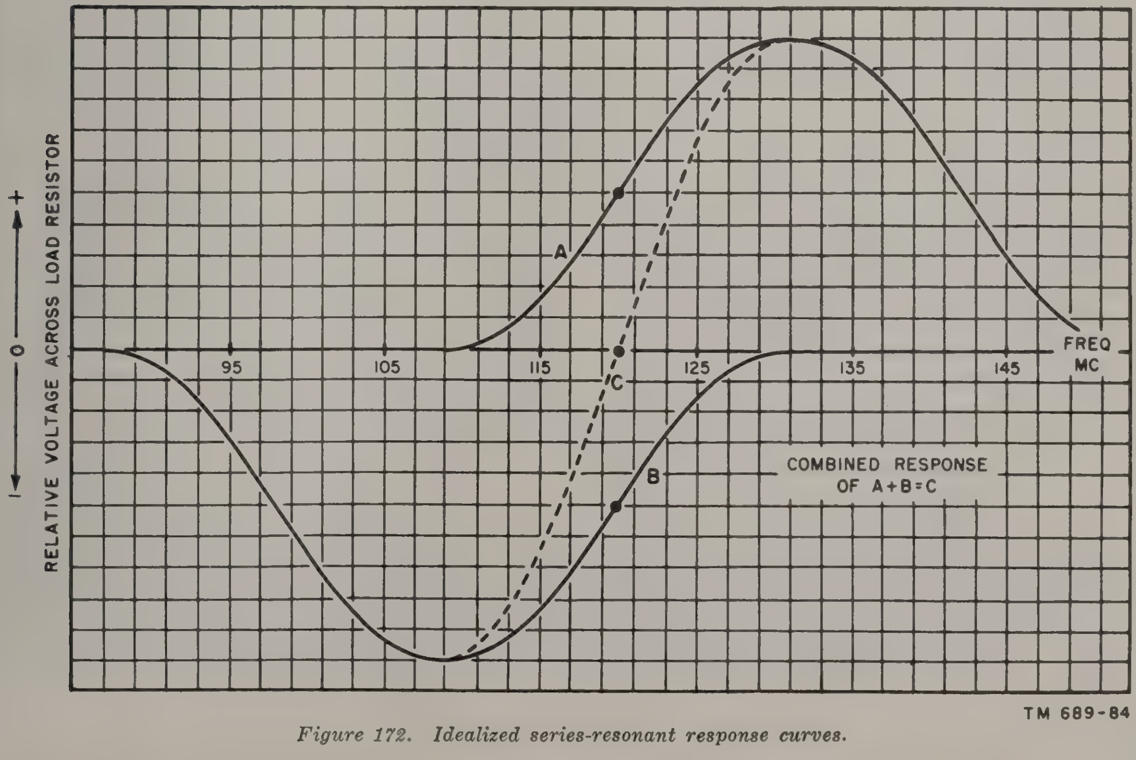


Figure 172. Idealized series-resonant response curves.

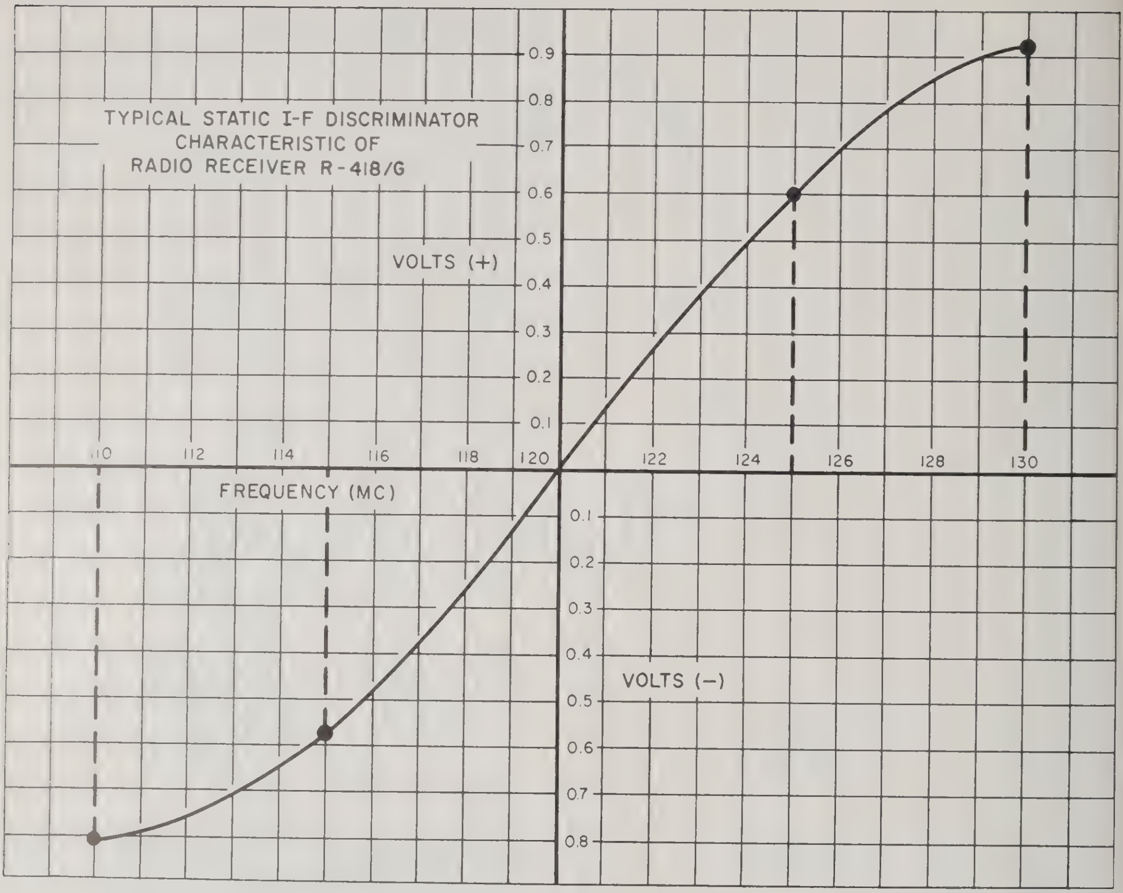


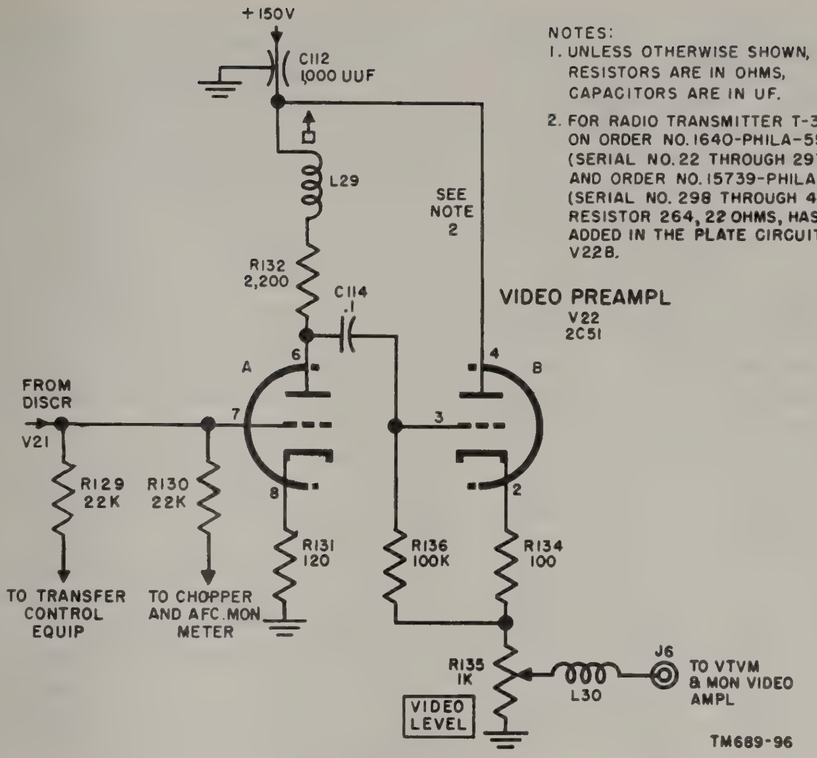
Figure 173. Typical static if. discriminator characteristic curves.

2. The video voltage developed in the plate circuit of V22A is coupled to the grid of V22B, a cathode follower, through capacitor C114. Resistor R136 is the grid-load resistor and R134 is the cathode-biasing resistor. The video voltage developed across VIDEO LEVEL control R135, which can be varied to provide the desired output level, is fed to VIDEO OUTPUT jack J6 through coil L30, which serves as an if. signal choke. This is the point at which the video voltage is obtained and fed to the video amplifier in the vtvm subchassis.

Note. For Radio Transmitter T-303/G on Order No. 1640–Phila–51 (serial No. 22–297) and Order No. 15739–Phila–55 (serial No. 298–417), resistor R264, 22 ohms, has been added in the plate circuit of V22B. This resistor was added to eliminate the tendency for parasitic oscillations in the prevideo amplifier.

(3) *Chopper amplifier circuits.*

(*a*) *General* (fig. 175). The discriminator dc output of the if. amplifier is applied to the chopper amplifier. To amplify the signal easily, a chopper is used to break up the dc into a train of rectangular pulses. Unlike conventional choppers that switch between two sources, this chopper


+150V
C112
1,000 UUF
L29
SEE
NOTE
2
R132
2,200
C114
.1
VIDEO PREAMPL
V22
2C51
6
4
A
B
FROM
DISCR
V21
7
3
8
2
R129
22K
R130
22K
R131
120
R136
100K
R134
100
TO TRANSFER
CONTROL
EQUIP
TO CHOPPER
AND AFC.MON
METER
R135
1K
VIDEO
LEVEL
L30
J6
TO VTVM
& MON VIDEO
AMPL
TM689-96

NOTES:
1. UNLESS OTHERWISE SHOWN, RESISTORS ARE IN OHMS, CAPACITORS ARE IN UF.
2. FOR RADIO TRANSMITTER T-303/G ON ORDER NO. 1640-PHILA-55 (SERIAL NO. 22 THROUGH 297) AND ORDER NO. 15739-PHILA-55 (SERIAL NO. 298 THROUGH 417), RESISTOR 264, 22 OHMS, HAS BEEN ADDED IN THE PLATE CIRCUIT OF V22B.

Figure 174. Video preamplifier V22, simplified schematic diagram.

gives a narrow pulse equal to the dwell time of the make before break of a series-connected switch pair. These pulses are directly proportional in amplitude and opposite in polarity to the dc voltage causing them. This rectangular pulse train is amplified by two conventional amplifiers, V23 and V24. The positive and negative outputs then are detected (rectified) by peak detector V25. The resulting dc voltages are used to actuate a relay control circuit that controls the operation of a motor drive system which, in turn, retunes the klystron in the direction that will reduce the dc signal.

(*b*) *Chopper amplifier V23* (fig. 176).

1. The discriminator output voltage is applied through terminal 8 of TB12 to the chopper input circuit. The chopper input circuit contains an RC network, R137, R138, R140, and C115, which serves as a voltage divider and filter. The time constant of this network is extremely long and integrates im-

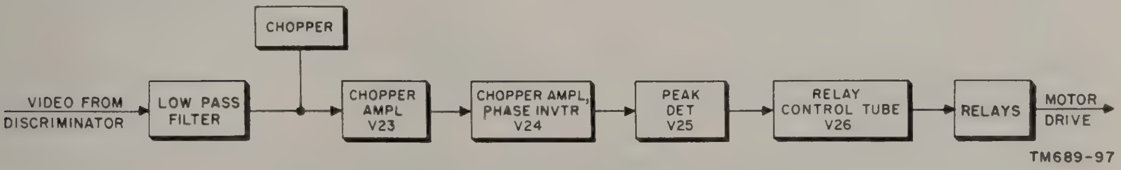

CHOPPER
VIDEO FROM
DISCRIMINATOR
LOW PASS
FILTER
CHOPPER
AMPL
V23
CHOPPER AMPL,
PHASE INVTR
V24
PEAK
DET
V25
RELAY
CONTROL TUBE
V26
RELAYS
MOTOR
DRIVE
TM689-97

Figure 175. Chopper amplifier circuits, block diagram.

pressed signals. The charging and discharging time is affected by R138 and C115, and by R137. Therefore, only very gradual changes in the output of the discriminator are applied to the chopper amplifier. The video signal and any momentary transients that may exist at the discriminator output are bypassed by C115 and are not applied to the chopper amplifier grid. For all practical purposes, the signal applied to the chopper amplifier grid may be considered to be a dc signal.

2. The dc signal is coupled to the grid of V23A through resistor R139. The grid of V23A, a 2C51 twin triode, also is connected to afc chopper K1. This chopper is operated by 6.3-volt, 50/60-cycle power applied to its coil. Application of this voltage causes the contacts of K1 to open and close continually. Its operation is somewhat analogous to that of a conventional vibrator power supply. When the contacts are closed, the grid of V23A is at ground potential. When the contacts are open, the dc signal obtained from the RC network is applied to the grid.

3. Figure 177 shows the input voltage waveforms obtained. The curve at A in this figure illustrates a typical dc voltage. This voltage is applied to the grid while the chopper contacts remain open. When the chopper contacts are grounded, the dc voltage is shorted out and the grid voltage is zero. Consequently, the resultant voltage is a train of rectangular pulses recurring at twice the chopper supply frequency, as shown at B in the figure. The applied voltage is shorted to ground approximately 10 percent of the

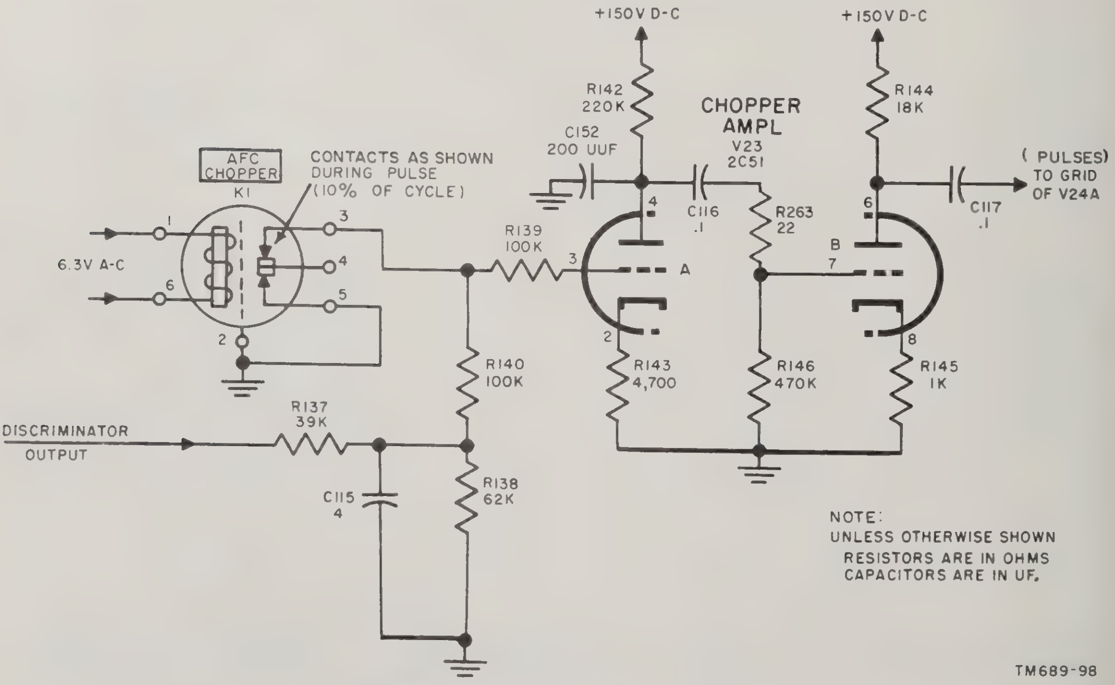

+150V D-C
+150V D-C
R142
220K
CHOPPER
AMPL
V23
2C51
R144
18K
C152
200 UUF
AFC
CHOPPER
K1
CONTACTS AS SHOWN
DURING PULSE
(10% OF CYCLE)
(PULSES)
TO GRID
OF V24A
C116
.1
R263
22
C117
.1
1
3
4
5
6
2
6.3V A-C
R139
100K
3
4
A
6
B
7
2
8
R140
100K
R143
4,700
R146
470K
R145
1K
DISCRIMINATOR
OUTPUT
R137
39K
C115
4
R138
62K
NOTE:
UNLESS OTHERWISE SHOWN
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UF.
TM689-98

Figure 176. Chopper amplifier V23, simplified schematic diagram.

time. When the dc voltage is positive in polarity, a train of negative rectangular pulses is applied to the grid.

4. The voltage applied to the grid of V23A appears across V23A plate-load resistor R142 as an amplified voltage. It is then coupled through C116 to the grid of V23B and further amplified by this stage. The voltage appearing across R144, the V23B plate-load resistor, is coupled through capacitor C117 to the grid of V24A. Resistors R143 and R145 are cathode-biasing resistors, and R146 is the grid resistor for V23B.

(*c*) *Chopper amplifier-inverter, V24* (fig. 178).

1. The rectangular pulses obtained from V23B are further amplified by V24A, one-half of a 2C51 twin triode. The amplified pulses appear across plate-load resistor R148 and are applied through capacitor C118 to the grid of phase inverter V24B, the other half of the 2C51. Output voltages are obtained across plate-load resistor R150 and cathode load resistor R153. These voltages are equal in amplitude but 180° out of phase. If the dc signal from the discriminator is positive, a negative rectangular voltage waveform appears across plate-load resistor R150, and a positive rectangular waveform appears across cathode load resistor R153. Conversely, if the applied dc signal is negative, a positive rectangular pulse appears across R150 and a negative pulse across R153.

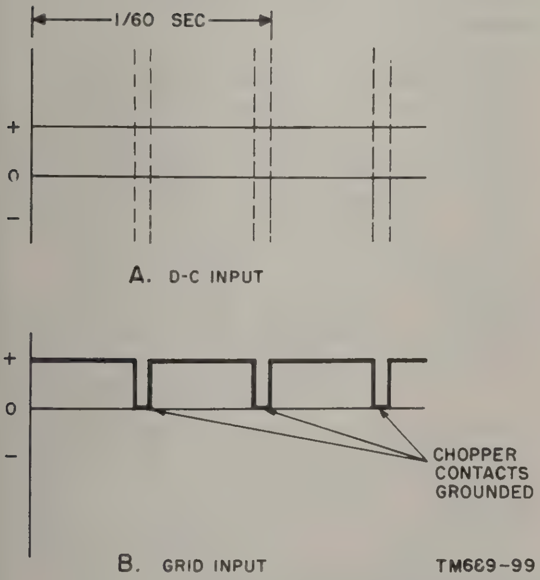


Figure 177. Chopper voltage waveforms.

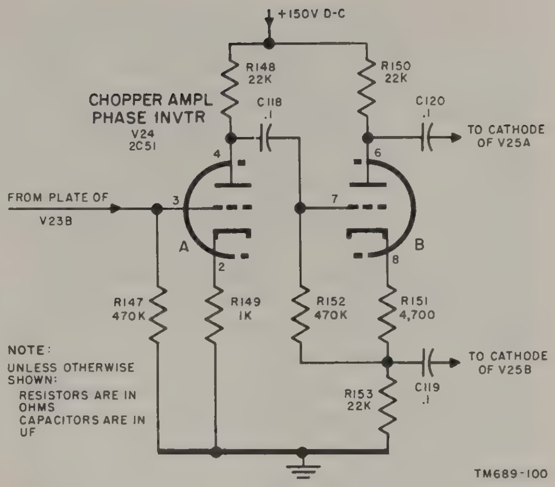

+150V D-C
R148 22K
R150 22K
CHOPPER AMPL PHASE INVTR
V24 2C51
C118 .1
C120 .1
TO CATHODE OF V25A
4
6
FROM PLATE OF V23B
3
7
A
B
2
8
R147 470K
R149 1K
R152 470K
R151 4,700
NOTE: UNLESS OTHERWISE SHOWN: RESISTORS ARE IN OHMS CAPACITORS ARE IN UF
TO CATHODE OF V25B
R153 22K
C119 .1
TM689-100

Figure 178. Chopper amplifier-inverter V24, simplified schematic diagram.

2. These output voltages are coupled to the cathodes of V25A and V25B through coupling capacitors C120 and C119, respectively. Resistors R149 and R151 are cathode-biasing resistors; R147 and R152 are grid resistors for V24A and V24B, respectively.

(*d*) *Peak detector V25* (fig. 179).

1. The outputs of the inverter are fed to the cathodes of V25A and V25B, two sections of a 6AL5W twin diode. When the input to the chopper amplifier is positive, a negative pulse from the plate of V24B is applied to the cathode of

V25A, and a positive pulse from the cathode of V24B is applied to the cathode of V25B. Consequently, only V25A conducts, developing a positive voltage across R154. At the same time, V25B appears as an open circuit.

2. Similarly, when the input to the chopper amplifier is negative, a positive voltage is applied to the cathode of V25A and a negative voltage to the cathode of V25B, then V25B conducts and results in a positive voltage across R155. If the input voltage is zero, neither diode conducts.

(*e*) *Relay control tube V26* (fig. 179).

1. The voltages developed across resistors R155 and R154 are applied to the grids of V26A and V26B, respectively. Both halves of V26, a 2C51 twin triode, are normally cut off because of the application of a fixed bias of about 6.5 volts to the cathodes of these tubes. The bias is obtained from the voltage-divided network, R157, R158 and R156, which is connected between the +150-volt supply and ground, through the break contacts of relays K2 and K3.

2. When a positive voltage is applied to either grid, the appropriate tube conducts. When the voltage applied to the chopper is positive, a positive voltage is applied to V26B across R154, and this tube conducts. When the applied voltage is negative, a positive voltage is applied to V26A across R155, and V26A conducts. Relays K2 and K3, in the plate circuits of these tubes, operate when a plate current about 2.5 ma is drawn,

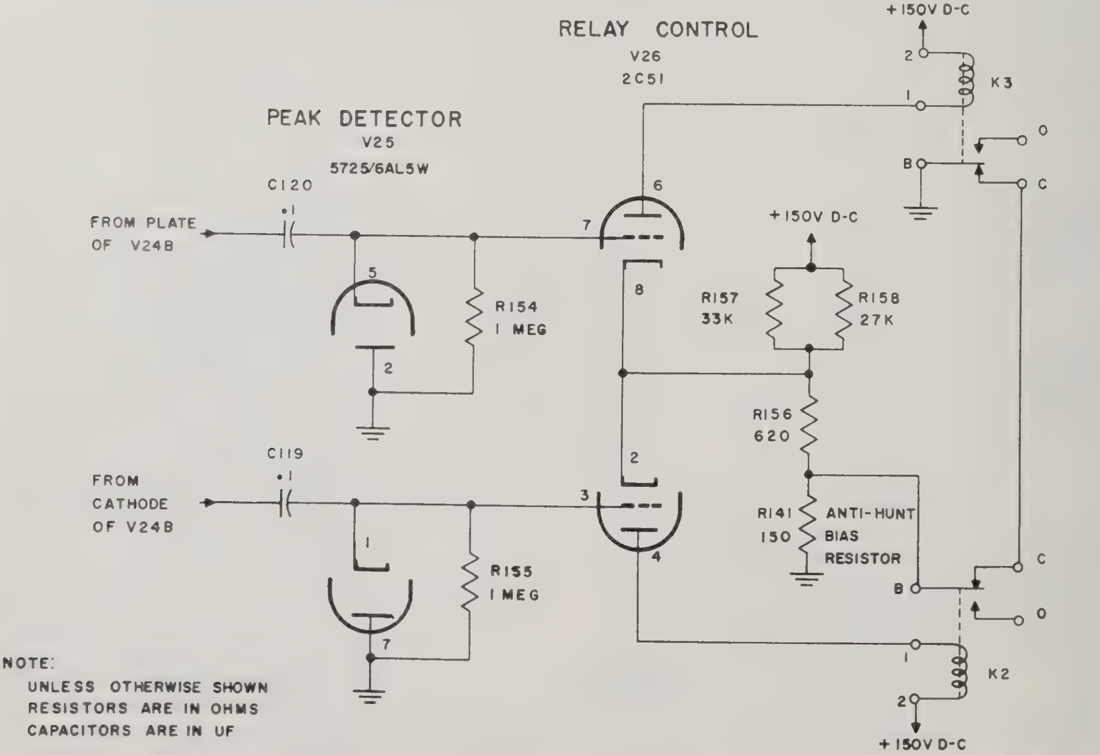

RELAY CONTROL
V26
2C51
PEAK DETECTOR
V25
5725/6AL5W
C120
.1
FROM PLATE OF V24B
C119
.1
FROM CATHODE OF V24B
R154 1 MEG
R155 1 MEG
R157 33K
R158 27K
R156 620
R141 150
ANTI-HUNT BIAS RESISTOR
+150V D-C
+150V D-C
+150V D-C
K3
K2
B
C
O
1
2
3
4
5
6
7
8
NOTE:
UNLESS OTHERWISE SHOWN
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UF
TM 689-201

Figure 179. Peak detector V25, relay control tube V26, and antihunt circuit, simplified schematic diagram.

and release at a plate current of about 0.5 ma. Therefore, a stronger signal is required to operate the relay than is required to hold it operated. Ordinarily, a change about 1 volt at the grid would be necessary to cause the 2-ma plate-current differential required for the relay to release. To increase the sensitivity of the circuit to grid voltage changes, resistor R141 is connected between ground and the lower end of the bias voltage divider for the tubes. The upper end of this resistor, at the junction of R156 and R141, is connected to a pair of break contacts in each of relays K2 and K3. These contacts are in series and, when both relays are deenergized, they connect this lead to ground, shorting out R141. When either relay is energized, the short is reremoved and R141 is in the circuit. This increases the bias on V26, placing the grid voltage near cutoff. This compensates for the relay current characteristic so that a difference in applied grid voltage about 0.1 volt in the proper direction will cause the relay to release if it is operated, or operate if it is released. Relay K2 is operated when V26A draws sufficient current, and K3 when V26B draws sufficient current. The operation of either K2 or K3 is determined by the polarity of the error voltage. The relays control the direction of rotation of the afc drive motor to retune properly the klystron to correct the frequency error; one relay for each direction.

(*f*) *Antihunt circuit.*

1. Hunting is the term applied to an undesirable characteristic inherent in any servomechanism (mechanical servo system). The transmitter afc circuits used in this equipment fall into the category of servomechanisms. The electrical portion of the feedback loop responds rapidly to error signals, but there is a relatively long time lag in the response time of the mechanical components. For instance, when the afc drive motor is running and its operating voltage is removed, it does not stop immediately despite dynamic braking, but coasts for a period of time, because of momentum. The operating voltage is not removed until the error signal reaches zero; therefore the mechanical drive will continue to run and overshoot the correct point. This will cause an error signal in the opposite sense, and the motor will drive in the reverse direction, again overshooting the desired point. The amount of overshoot acts like a damped oscillation and becomes smaller with each succeeding cycle, but continues for some time searching for a point of equilibrium that satisfies the balance conditions of the feedback circuit. This process is known as hunting.

2. Resistor R141 is placed in the cathode circuit of V26 (fig. 179) to provide an antihunt action. This circuit is arranged so that when either relay K2 or K3 is operated, R141 is inserted in series between cathode resistor R156 and ground. When both relays are released, R141 is shorted out. When R141 is in the circuit, the bias on V26 is increased ((*e*)*2* above), causing the sensitivity of the circuit to be increased by a factor of about 10. The added sensitivity means that less voltage change at the grid of V26 is needed to cut the tube off; therefore the required grid cutoff voltage is reached sooner during a motor-operating cycle, effectively causing the circuit to *anticipate* a satisfactory condition, and remove power from the motor earlier than would otherwise be the case. Because of the mechanical time lag, the discriminator output is very nearly zero by the time the motor stops. The reduction of bias which occurs when the relay releases and R141 is shorted out does not permit sufficient current to flow through the tube to reoperate the relay.

3. Relays K2 and K3 together act as a differential relay. When both are released, the motor stops. When one is operated, the motor runs in one direction; when the other is operated, the motor runs in the opposite direction. The operation of the motor is caused by the *removal* of current from one winding, rather than by its application ((4)(*b*), below). When both relays are released, power is applied to both motor windings. These windings are phased to oppose each other electrically, so that the motor cannot run in either direction. When power is removed from one winding, the power in the other winding plus the voltage coupled through C150 causes the motor to rotate. These conditions effectively create a fail-safe circuit. If one relay or one-half of V25 or V26 fails, the motor can rotate in one direction, but not in the other. This will cause the klystron frequency to remain off its assigned value sufficiently to operate the alarm circuit. If any of the preceding components fail and neither relay operates, the motor is prevented from rotating and the klystron tuning setting will not change, regardless of frequency deviations and consequent afc input signals, likewise causing an alarm indication.

(4) *Afc drive motor system* (fig. 180).

(*a*) *General.*

1. The drive motor system consists of the output circuits of the chopper amplifier plus a number of switching circuits that control the motion of the frequency-error correction motor. Figure 180 is an overall schematic diagram showing all the components of the afc drive motor system. Some of these components are physically located on the chopper amplifier subchassis. Others are located on the main transmitter chassis.

2. The chassis elements of the afc drive system include the following: the output circuits of the chopper amplifier; afc motor B1; afc motor capacitor C150; AFC ON–OFF switch S9, which enables an operator to disconnect the 6.3-volt ac power from the coil of chopper K1, disabling the entire afc system; AFC–MANUAL SWITCH S6, which enables the operator to operate either K2 or K3, following the chopper amplifier relay control stage, thereby obtaining manual klystron frequency adjustment; and two cam detent microswitches, which limit the amount of motor rotation.

(*b*) *Normal AFC–ON operation.*

1. Assume that the klystron is *on frequency.* Neither K2 nor K3 is energized. One hundred and fifteen volts ac are applied from terminal pin W of P26 to point A (yellow lead) on motor B1. One hundred and fifteen volts ac are applied also to point B (red lead) of motor B1 from terminal 5 of TB12B, through contacts C–A of relay K3 and pin T of P26. The motor ac return (green lead) is through terminal P of P26 to terminal 10 of TB12B.

2. Motor B1 is a 2-pole, induction-type torque motor with a built-in gear train, and is reversible in rotation. When ac is applied to both sides of the motor capacitor (points A and B), the motor is dynamically braked. Consequent-

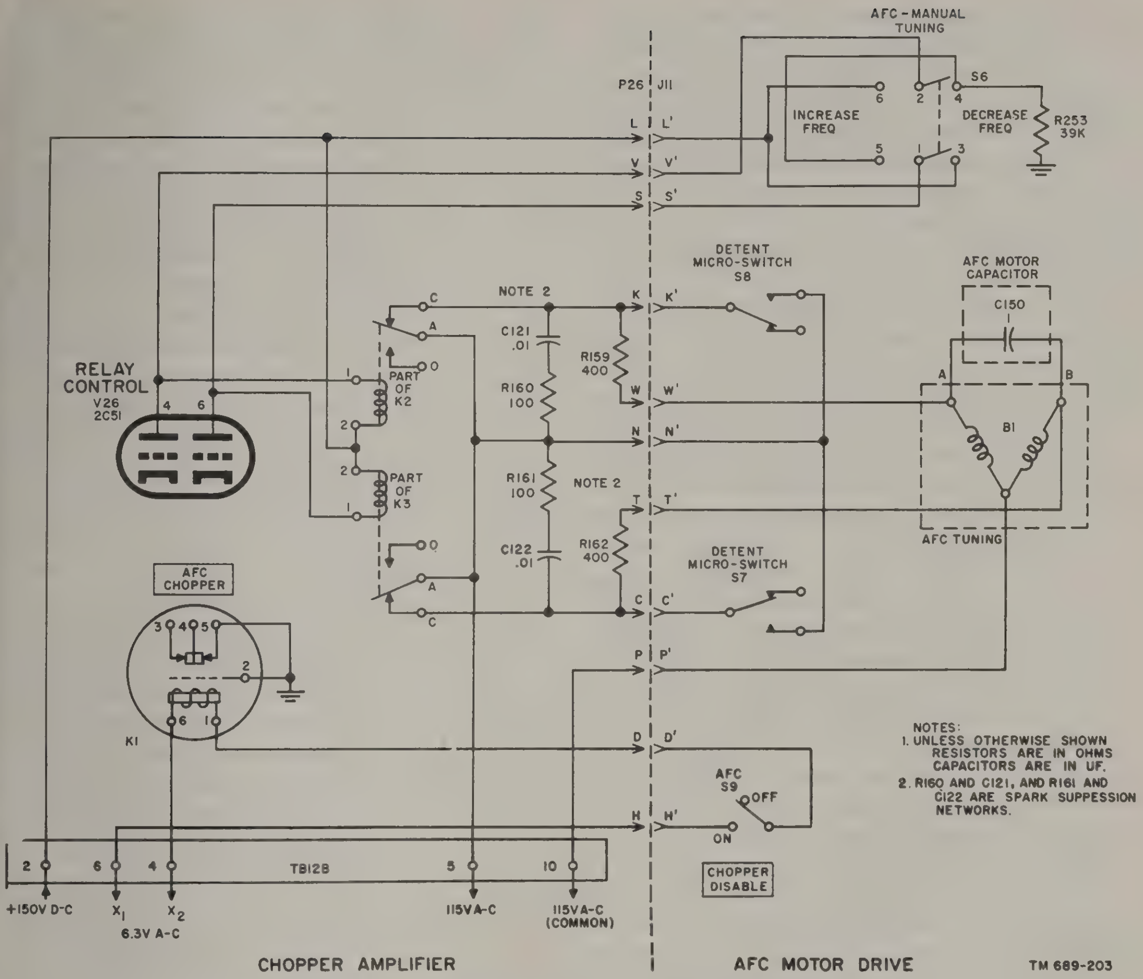

AFC-MANUAL TUNING
P26
J11
S6
INCREASE FREQ
DECREASE FREQ
R253 39K
6
2
4
5
1
3
L
L'
V
V'
S
S'
DETENT MICRO-SWITCH S8
AFC MOTOR CAPACITOR
C150
NOTE 2
C
A
O
K
K'
C121 .01
R159 400
RELAY CONTROL V26 2C51
4
6
1
PART OF K2
2
R160 100
W
W'
A
B
B1
N
N'
2
PART OF K3
1
R161 100
NOTE 2
T
T'
AFC TUNING
AFC CHOPPER
C122 .01
R162 400
O
A
C
DETENT MICRO-SWITCH S7
C
C'
3
4
5
2
6
1
K1
P
P'
D
D'
NOTES:
1. UNLESS OTHERWISE SHOWN RESISTORS ARE IN OHMS CAPACITORS ARE IN UF.
2. R160 AND C121, AND R161 AND C122 ARE SPARK SUPPRESSION NETWORKS.
AFC S9
OFF
ON
H
H'
CHOPPER DISABLE
TB12B
2
6
4
5
10
+150V D-C
X1
X2
6.3V A-C
115VA-C
115VA-C (COMMON)
CHOPPER AMPLIFIER
AFC MOTOR DRIVE
TM 689-203

Figure 180. Control, relay, and afc motor drive circuit, simplified schematic diagram.

ly, with K2 and K3 not operated, the motor is in a stopped condition.

3. Assume now that the klystron frequency shifts to a lower value. This causes the application of a positive voltage to the chopper and results ultimately in the operation of relay K3. This removes ac from point B of the motor and causes the motor to rotate counterclockwise (as viewed from the shaft end). The motor is mechanically coupled to the fine-tuning adjustment screw of the klystron. With the motor turning counterclockwise, the klystron frequency is increased, bringing it back toward the correct value.

4. Assume now that the klystron shifts to a higher frequency. This causes the application of a negative voltage to the chopper and results ultimately in the operation of relay K2. This removes ac from point A of the motor and causes the motor to rotate clockwise, decreasing the klystron frequency.

5. Resistors R159 and R162 are

peak-current, transient-limiting resistors that reduce the peak currents generated when either of the two sets of relay contacts opens. Resistor R160 and capacitor C121, and R161 and C122 are microswitch arc-suppression networks.

(*c*) *Operation of limit switches S7 and S8.*

1. Detent microswitches S7 and S8 are wired in parallel with the contacts of relays K2 and K3, respectively. Switch S7 limits the rotation of the motor in the clockwise direction; S8 limits its rotation in the counterclockwise direction. If these limit switches were not incorporated it would be possible, under certain conditions, for the motor to run continuously in one direction and damage the klystron.

2. The limit switches are actuated by a circular cam with two detents. This cam is mounted on the motor shaft. Each switch has a roller arm that bears on the circular cam. When the motor shaft has turned about 180° in either direction, the roller on one switch or the other reaches the detent involved, and the switch is actuated.

3. In normal operation, switches S7 and S8 are open (fig. 180). Assume that relay K2 is actuated, causing the motor to turn clockwise, because ac has been removed from point A. When the rotation causes the cam detent to reach switch S7, the switch is closed. Ac voltage is now applied to point A from terminal 5 of TB12B, through pin N of P26, switch S7, and pin K of P26, and the motor is dynamically braked. Similarly, if K3 is actuated, the motor rotates counterclockwise until the detent is reached, which actuates switch S8. With S8 actuated, ac voltage is applied to point B through S8 and pin C of P26, and the motor is braked.

(*d*) *AFC–MANUAL TUNING switch S6.*

1. AFC–MANUAL TUNING switch S6 can be used to operate either K2 or K3. These relays normally are operated by current flowing through tube V26, with switch S6 in the center position. When switch S6 is placed in the down position (terminals 2 and 4 making contact), relay K2 is actuated (as though the klystron frequency were high), because a dc path to ground through the relay coil is provided through R253 from the 150-volt supply. At the same time, contacts 1 and 3 of S6 short-circuit the coil of relay K3 so that this relay cannot be actuated. With K2 operated, the motor turns in a clockwise direction and the klystron frequency is lowered.

2. When switch S6 is placed in the up position, relay K3 is operated by completion of the dc path from the 150-volt supply through the coil of K3, contacts 2 and 6 of S6, and resistor R253, to ground. At the same time, contacts 1 and 5 short-circuit the coil of relay K2. With K3 energized, the motor turns in a counterclockwise direction and the klystron frequency is increased.

(*e*) *AFC ON–OFF switch S9.* 6.3-volt ac power for the coil of chopper K1 is obtained from terminal 6 of TB-12B through pin H of P26, AFC ON–OFF switch S9, and pin D of P26. In the ON position, S9 applies power to coil K1. In the ON position, S9 applies power to coil K1. If this switch is in the OFF position, however, primary power is not applied to chopper K1. In this condition, the chopper amplifier input is grounded, and neither K2 nor K3 can be energized by the afc signal, thus disabling the system.

167. Vtvm Subchassis

a. General. The vtvm subchassis actually consists of four separate operating sections:

(1) Sawtooth generator V27 delivers an adjustable-amplitude sawtooth test signal to the modulator input for checking system performance.

(2) The vtvm consists of a 3-stage video amplifier (V28–V30), peak detector V31, and peak voltage (positive and negative) dc amplifier V32 that, in conjunction with PEAK VTVM meter M4, indicates positive or negative voltage peaks, depending on the position of POS PEAK–NEG PEAK switch S5. It is used for checking modulation levels at different points in the transmitter. In conjunction with its associated meter and meter switches in the meter panel, the vtvm monitors the modulator input, modulator output, both in terms of peak voltage, and monitor video output, in terms of percent modulation. This meter has two scales: one calibrated directly in peak volts and the other calibrated in percent modulation.

(3) Monitor amplifier V33 matches the impedance of the video output of the video preamplifier in the if. amplifier subchassis to the 50-ohm, coaxial-cable, terminating impedance.

(4) The order-wire carrier monitor amplifier is used to indicate, by a lamp on the meter panel, the presence of the order-wire carrier and to give a meter indication of the order-wire carrier level. This amplifier also furnishes an order-wire carrier alarm signal that controls the operation of the transfer control equipment (when available). The order-wire monitor circuits consist of amplifier V34, peak detector V35, relay control tube V36, and relay K4.

b. Block Diagram Description (fig. 181).

(1) *Sawtooth oscillator.* Sawtooth oscillator V27 is used to generate a sawtooth voltage waveform, which may be coupled to the modulator to be used in testing the operation of the transmitter but not for a final system level adjustment. It is located on the vtvm subchassis for reasons of mechanical convenience. Its 1-stage circuit uses a 2C51 twin triode as a sawtooth oscillator, having a common cathode resistor for the feedback path. The sawtooth wave is formed by the charging and discharging of a capacitor in the output circuit, the output voltage being obtained from the arm of the ST LEVEL potentiometer. The operating frequency of the sawtooth oscillator is approximately 500 cps, and the output level is sufficient to drive the modulator to provide 100 percent modulation of the carrier. The output signal appears at ST OUTPUT jack J8 and is connected by a coaxial cable to the modulator. The waveform is not exactly symmetrical and the normal positive to negative peak ratio is 85 to 110. See paragraph 233*i*(7). The signal, therefore, cannot be used as a level adjustment for balanced signals; for instance, 45-channel operation.

(2) *Vacuum-tube voltmeter.* VTVM SEL SW S2, mounted on the vtvm subchassis, selects the MOD INPUT or MOD OUTPUT signals from the modulator, or the MON OUTPUT signal from the video preamplifier in the if. strip. An additional switch position grounds the vtvm input and is used for zeroing the meter before making measurements. The signal selected by S2 is fed to the grid of first video amplifier V28, which amplifies it and sends it on through V29, then through V30, the second and third video amplifiers, respectively. These are all 6AG7 tubes, connected in a feedback circuit. From the output of V30, the signal enters peak detector stage V31, which detects the positive and negative peaks of the video signal. The resultant dc is passed through S5 on the meter panel, which selects either the positive or negative peak signal to be indicated on the PEAK VTVM meter. Switch S5 also selects a dc amplifier balancing voltage for zeroing the meter. These voltages are

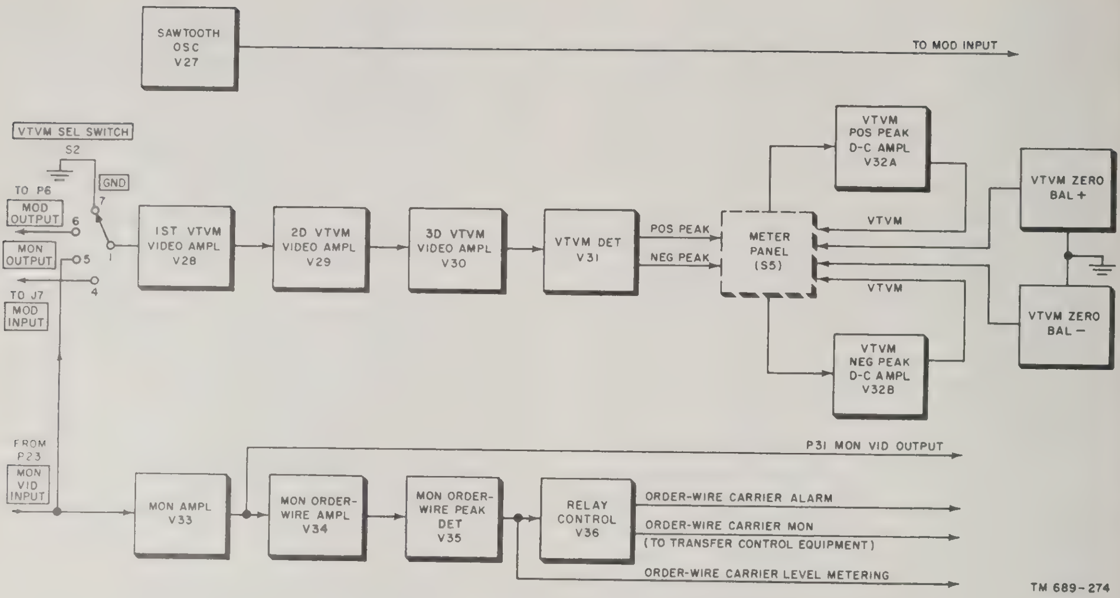

SAWTOOTH OSC V27
TO MOD INPUT
VTVM SEL SWITCH
S2
GND
TO P6
MOD OUTPUT
MON OUTPUT
TO J7
MOD INPUT
7
6
5
4
1
1ST VTVM VIDEO AMPL V28
2D VTVM VIDEO AMPL V29
3D VTVM VIDEO AMPL V30
VTVM DET V31
POS PEAK
NEG PEAK
METER PANEL (S5)
VTVM POS PEAK D-C AMPL V32A
VTVM
VTVM
VTVM NEG PEAK D-C AMPL V32B
VTVM ZERO BAL +
VTVM ZERO BAL −
FROM P23
MON VID INPUT
MON AMPL V33
MON ORDER-WIRE AMPL V34
MON ORDER-WIRE PEAK DET V35
RELAY CONTROL V36
P31 MON VID OUTPUT
ORDER-WIRE CARRIER ALARM
ORDER-WIRE CARRIER MON
(TO TRANSFER CONTROL EQUIPMENT)
ORDER-WIRE CARRIER LEVEL METERING
TM 689-274

Figure 181. Vtvm subchassis, block diagram.

returned to the vtvm subchassis, where they are applied to dc amplifier V32, amplified, then sent back to the meter panel to be displayed on PEAK VTVM meter M4.

(3) *Order-wire monitor circuits.*

(*a*) The order-wire monitor provides a means of indicating the presence of the order-wire carrier in the main rf signal. The order-wire carrier is the only signal that is present at all times when the transmitter is operating properly. Thus, the presence of the order-wire signal indicates that the main transmitter is functioning properly. Absence of the order-wire signal, though it could be caused by other reasons, indicates transmitter failure. If the order-wire carrier is present, the TRANSMITTER OPERATING indicator lamp lights. At the same time, 115 volts ac, which was applied to the order-wire alarm circuit, is removed.

(*b*) A 6-mc order-wire carrier signal from the monitor amplifier is fed to monitor order-wire amplifier V34, a 5654/6AK5W. After amplification, the order-wire carrier signal is fed to monitor order-wire diode detector V35, a 6AL5W, which rectifies and doubles the signal voltage. This dc voltage drives V36, a 2C51 relay control tube. The tube is normally conducting (with order-wire carrier present), holding relay K4 operated. When the carrier disappears, there is no dc voltage present at the grid and the relay releases.

c. Detailed Circuit Description.

(1) *Sawtooth oscillator V27* (fig. 182).

(*a*) Tube V27, a 2C51 dual triode, is a sawtooth oscillator, operating at a frequency of approximately 500 cps. The output of this circuit is fed directly to the modulator subchassis for modulating the klystron. The output level may be adjusted to obtain 100 percent modulation. The basic method of obtaining the sawtooth voltage is by the charge and discharge of capacitor C125. Capacitor C125 charges up toward the +150-volt dc supply level while V27B is cut off, and discharges through V27B while it is conducting.

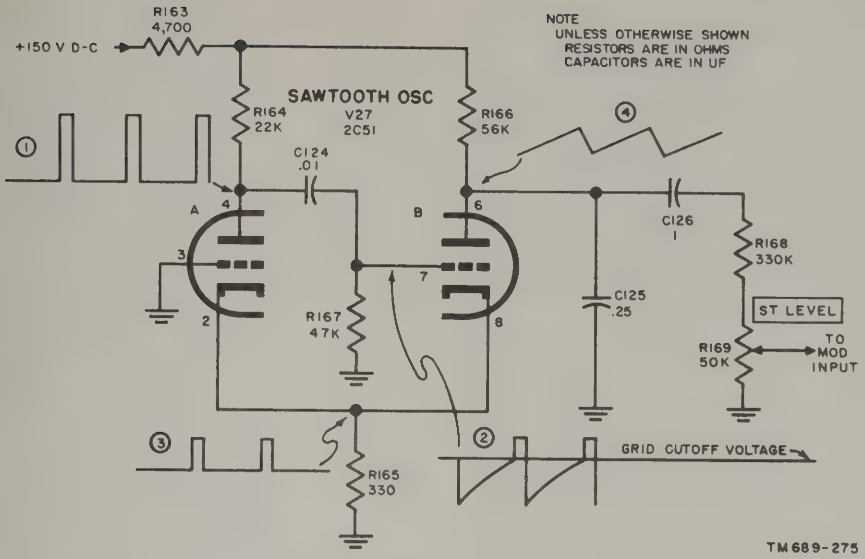

R163
4,700
+150 V D-C
NOTE
UNLESS OTHERWISE SHOWN
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UF
SAWTOOTH OSC
R164
22K
V27
2C51
R166
56K
④
①
C124
.01
A
4
3
2
B
6
7
8
C126
1
R168
330K
C125
.25
ST LEVEL
R167
47K
R169
50K
TO
MOD
INPUT
③
②
GRID CUTOFF VOLTAGE
R165
330
TM689-275

Figure 182. Sawtooth oscillator V27, simplified schematic diagram.

(*b*) Assume that at a given instant tube V27A is conducting and V27B is cut off. Tube V27A is conducting because its grid is at ground potential and the cathode bias developed across common cathode resistor R165 is insufficient to cut the tube off. Tube V27B is cut off because C124, which has been charged, is discharging toward a lower value of V27A plate voltage (caused by the voltage drop across plate resistor R164) and, as a result, is placing a negative bias on the grid of V27B. In this condition, C125 is charging up toward +150 volts through resistors R166 and R163.

(*c*) After a period of time, determined by the time constant of R167 and C124, C124 has discharged sufficiently to permit the V27B grid voltage to rise above cutoff. This allows V27B to conduct. With V27B conducting, the cathode bias increases and cuts off V27A. This applies a positive pulse to the grid of V27B through C124, which charges up to the higher plate voltage through the low grid-cathode impedance path of V27B. Capacitor C125 discharges rapidly, and the plate voltage of V27B decreases accordingly, until the combination of the high cathode bias and low plate voltage again drives V27B beyond cutoff. This permits V27A to conduct once more, and the cycle is repeated.

(*d*) The period of conduction of V27A (fig. 182) when plate voltage is minimum is much greater than the cutoff period when the plate voltage is maximum. The conduction period is determined mainly by the period of time required for the grid of V27B to go (in a positive direction) from its maximum negative value to the cutoff value. The V27A cutoff period is a function of the time constant of C125 and V27B plate-cathode impedance when the tube is conducting. Because the conduction period of V27A is much greater than the cutoff period, the sawtooth frequency is determined mainly by the C124–R167 time constant.

(*e*) The plate voltage of V27B (waveform 4) rises gradually as C125 charges up while this tube is cut off, and drops sharply as C125 discharges while the tube is conducting. This sawtooth voltage is coupled through capacitor C126, voltage-dividing network (R168 and R169, and J8), to the modulator input. The output voltage is taken from the arm of ST LEVEL potentiometer R169, which can be adjusted to provide the desired output voltage.

(2) *Vacuum-tube voltmeter.*

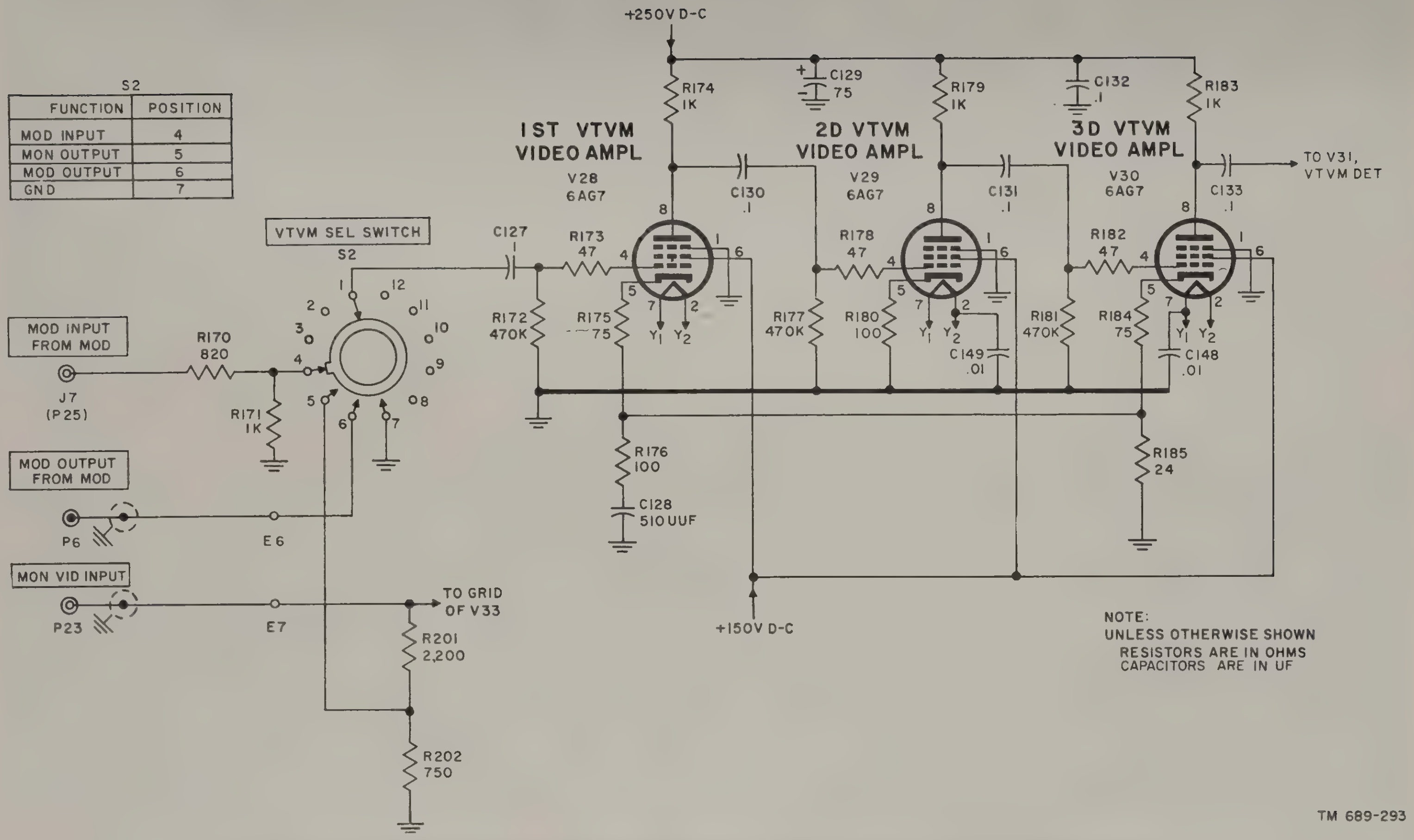
(*a*) *Input circuit* (fig. 183). The vtvm can be switched by VTVM SEL SW S2 to any of three monitoring points: modulator input obtained from J7 and fed to the input of the video amplifier through MOD INPUT (position 4) of S2; modulator output from P6 and fed through MOD OUTPUT (position 6) of S2; and transmitter video output (which indicates degree of modulation) through a voltage divider from P23 and fed through MON OUTPUT (position 5) of S2. The modulator input voltage is attenuated by a voltage divider comprised of R170 and R171, and the monitor video input voltage is attenuated by a voltage divider consisting of R201 and R202. When S2 is at GND (position 7), the input is grounded, corresponding to a zero-signal input. This position is used in conjunction with the positive and negative balance potentiometers to zero the meter electrically by balancing the amplifier currents.

(*b*) *Video amplifiers, V28 through V30* (fig. 183).

1. The video amplifiers consist of three stages using 6AG7 pentodes with overall feedback. The input signal selected by switch S2 is applied to the grid of the first video amplifier, V28, through coupling capacitor C127, and parasitic suppressor R173. The amplified video voltage obtained across plate-load resistor R174 is coupled to the second video amplifier through coupling capacitor C130 and parasitic suppressor R178. The amplified voltage obtained across V29 plate-load resistor R179 then is fed to the third video amplifier, V30, through capacitor C131 and parasitic suppressor R182. The voltage developed across plate-load resistor R183 is fed to the peak detector. Because the video amplifier has an odd number of stages, a phase reversal is introduced into the peak detector input signal. That is, a positive-going pulse at the input to the amplifier (V28) will emerge as a negative pulse to the peak detector (V31), and vice versa.

2. The cathodes of V28 and V30 use common load resistor R185. Thus, a portion of the video voltage developed in the third video amplifier is fed back to the first amplifier. Because the feedback voltage from V30 passes through two amplifiers, each shifting its phase by 180°, it is in phase with the signal applied to the grid of V28. It acts degeneratively. This feedback voltage reduces distortion and stabilizes the overall voltage gain of the amplifier system about 23.

3. Resistor R176 and capacitor C128 in series, both in shunt with the cathode load and feedback resistor R185, form a high-frequency compensation circuit. At low frequencies, this circuit presents a relatively high shunt impedance, and therefore does not greatly affect the feedback circuit. At high frequencies, however, the impedance of this circuit is small enough to reduce effectively the shunt feedback resistance and thereby reduce the feedback voltage. This increases the overall gain of the amplifier at these high frequencies. Without the R176–C128 circuit, the frequency response of the video amplifier would be flat from 30 cps to 0.5 mc and down 3 db at 8 mc. With the high-frequency compensation, the



+250V D-C
S2
VTVM SEL SWITCH
S2
MOD INPUT FROM MOD
J7
(P25)
MOD OUTPUT FROM MOD
P6
MON VID INPUT
P23
R170
820
R171
1K
E6
E7
TO GRID OF V33
R201
2,200
R202
750
1ST VTVM VIDEO AMPL
V28
6AG7
2D VTVM VIDEO AMPL
V29
6AG7
3D VTVM VIDEO AMPL
V30
6AG7
C127
.1
R172
470K
R173
47
R174
1K
R175
75
R176
100
C128
510UUF
C129
75
C130
.1
R177
470K
R178
47
R179
1K
R180
100
C149
.01
C131
.1
C132
.1
R181
470K
R182
47
R183
1K
R184
75
C148
.01
R185
24
C133
.1
TO V31, VTVM DET
+150V D-C
Y1
Y2
NOTE:
UNLESS OTHERWISE SHOWN
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UF
TM 689-293

S2

FUNCTION	POSITION
MOD INPUT	4
MON OUTPUT	5
MOD OUTPUT	6
GND	7

Figure 183. Vtvm input circuit and video amplifiers V28 through V30, simplified schematic diagram.

response is flat from 30 cps to 5.0 mc and is down 3 db at 9.0 mc.

4. Resistors R172, R177, and R181 are grid resistors for the first, second, and third amplifier stages, respectively. Resistors R175, R180, and R184 serve as cathode-biasing resistors for these stages. Resistors R175 and R184 also affect the feedback network, because they are in series with R185 and R176–C128. Capacitors C129 and C132 are video bypass capacitors for the +250-volt supply.

(*c*) *Peak detector circuit V31* (fig. 184).

1. The output of the video amplifier is coupled through C133 to V31, a 6AL5W twin diode. When the input signal is positive, V31A conducts, charging capacitor C134 to the peak of the applied voltage. When the signal voltage returns to zero, the capacitor discharges slowly through R188, a very high resistance (3.3 megohms). The capacitor recharges during the next positive period and the cycle is repeated. The time constant of C134–R188 is very high, the capacitor therefore discharges only very slightly between cycles and, for most practical purposes, the voltage across the capacitor can be considered equal to the peak input voltage. Similarly, when a negative signal is applied to the circuit, V31B conducts and charges C135 to the peak voltage.

2. A phase reversal occurred in the 3-stage video amplifier; therefore a negative voltage appearing across C135 corresponds to the application of positive pulses at the input to the video amplifier. Consequently, based on the polarity of the input signal, the output of this stage is called the *positive* peak, although it is actually a negative voltage. In the same manner, the positive voltage obtained across C134 is called the *negative* peak.

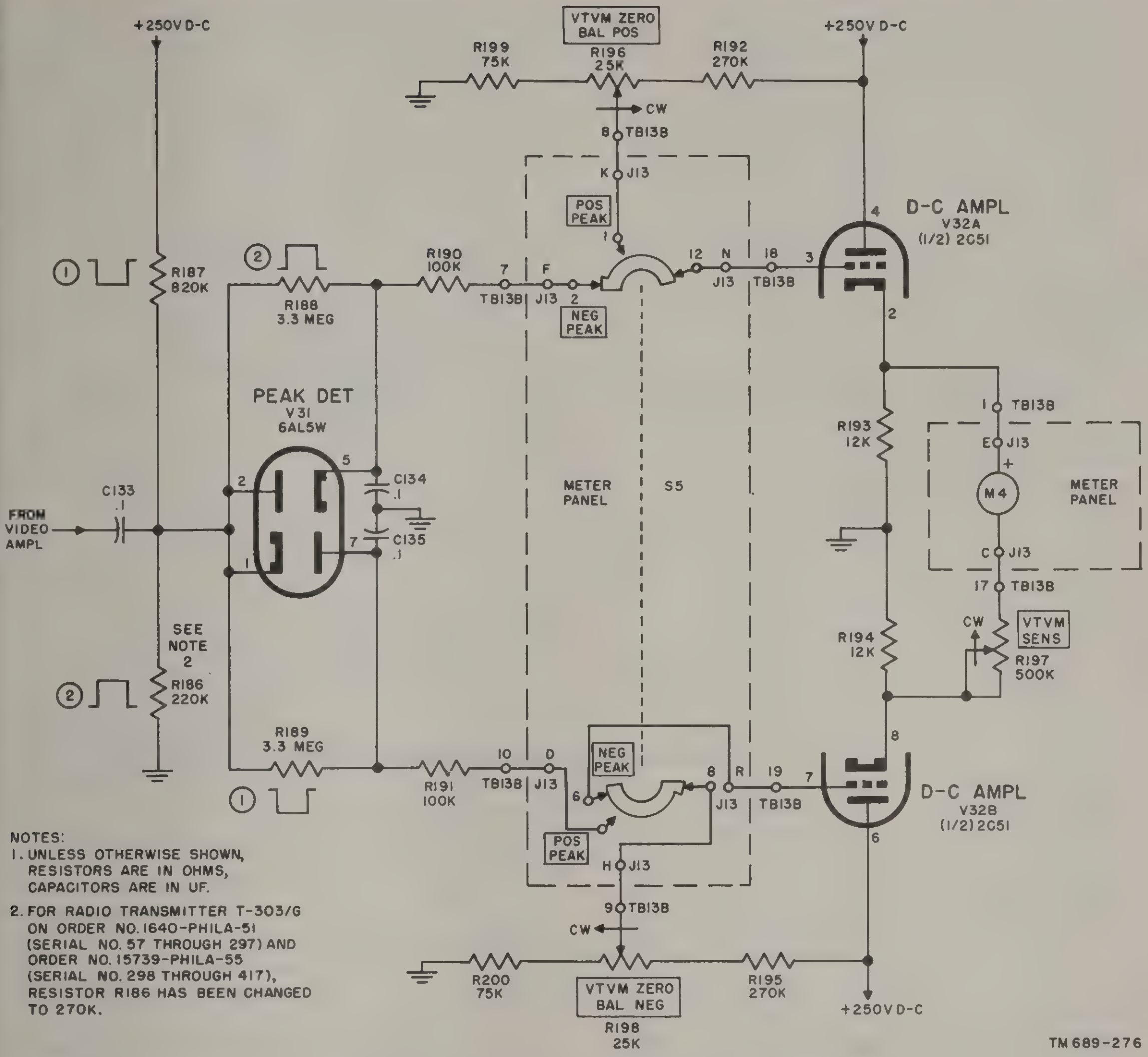
3. The outputs of the peak detectors are fed to the meter panel subchassis through terminals 7 and 10 on TB13B, and are introduced into this subchassis through pins F and D of J13. Here, either the *positive* or *negative* peak voltage and the positive or negative balancing voltage from R196 or R198 is applied to the dc amplifier.

(*d*) *Dc amplifier V32 and meter circuit* (fig. 184).

1. The dc amplifier, V32, a 2C51 twin triode, operates as follows: with no signal applied to either grid, the two tubes are adjusted to draw equal currents. When this condition exists, the voltage at the cathode of V32A across R193 is equal to the voltage at the cathode of V32B across R194. There is no voltage difference across the meter circuit of VTVM SENS potentiometer R197 and PEAK VTVM meter M4; therefore, a zero meter reading is obtained.

2. When switch S5 is in the NEG PEAK position, VTVM ZERO BAL NEG potentiometer R198 is adjusted for a zero meter reading with the input to the video amplifier grounded (VTVM SEL SW in position 7). When S5 is in the POS PEAK position, VTVM ZERO BAL POS potentiometer R196 is adjusted for a zero meter reading with the input to the video amplifier grounded.

3. Application of a negative pulse to the video input causes a positive voltage to exist across C134. With switch S5 in NEG PEAK position, this voltage is applied to the grid of V32A, increasing the tube current flow; consequently a potential difference exists across the meter circuit, providing a meter reading. The magnitude of the meter reading is proportional to the value of the peak voltage applied at the grid of V32A.


+250V D-C
VTVM ZERO BAL POS
R199 75K
R196 25K
R192 270K
+250V D-C
CW
8 TB13B
K J13
POS PEAK
1
12 N
18
3
4
D-C AMPL
V32A
(1/2) 2C51
R187 820K
R188 3.3 MEG
R190 100K
7 F
TB13B J13 2
NEG PEAK
J13 TB13B
2
PEAK DET
V31
6AL5W
1 TB13B
R193 12K
E J13
+
M4
METER PANEL
C133 .1
FROM VIDEO AMPL
2
5
C134 .1
7
C135 .1
1
METER PANEL
S5
C J13
17 TB13B
SEE NOTE 2
CW
VTVM SENS
R194 12K
R197 500K
R186 220K
R189 3.3 MEG
10 D
TB13B J13
R191 100K
NEG PEAK
6
8 R
19
7
J13 TB13B
8
D-C AMPL
V32B
(1/2) 2C51
6
POS PEAK
H J13
9 TB13B
CW
R200 75K
VTVM ZERO BAL NEG
R198 25K
R195 270K
+250V D-C
TM 689-276

NOTES:

1. UNLESS OTHERWISE SHOWN, RESISTORS ARE IN OHMS, CAPACITORS ARE IN UF.
2. FOR RADIO TRANSMITTER T-303/G ON ORDER NO. 1640-PHILA-51 (SERIAL NO. 57 THROUGH 297) AND ORDER NO. 15739-PHILA-55 (SERIAL NO. 298 THROUGH 417), RESISTOR R186 HAS BEEN CHANGED TO 270K.

Figure 184. Vtvm peak detector and dc amplifier circuit V31 and V32, simplified schematic diagram.

4. The setting of VTVM SENS potentiometer R197 is such that the overall vtvm sensitivity is about 0.5-volt rms for full-scale deflection. The meter scale has two sets of calibrations: one reading peak volts from 0 to 100, and the other (in red) reading percent modulation. The meter circuits are calibrated so that the meter reading on the 0 to 100 scale reads actual modulator output peak voltage. A half-scale reading on the percent modulation scale represents 100 percent modulation on the monitor video input circuit.
5. Similarly, application of a positive pulse to the video amplifier input provides a negative voltage across C135. With switch S5 in the POS PEAK position, this voltage is applied to the grid of V32B, decreasing the tube current which decreases the voltage across R194. This creates a potential difference across the meter circuit that is

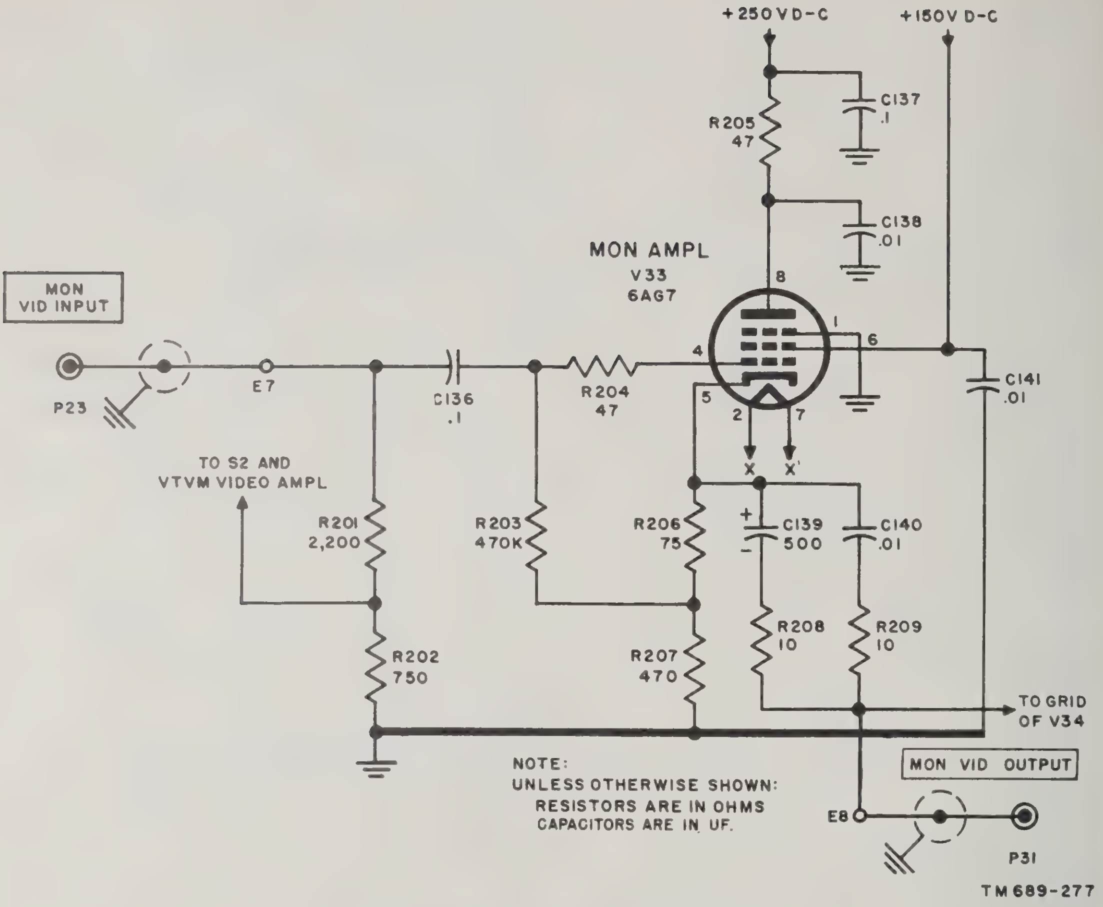

+250V D-C
+150V D-C
C137
.1
R205
47
C138
.01
MON AMPL
V33
6AG7
8
MON
VID INPUT
1
6
4
C141
.01
P23
E7
C136
.1
R204
47
5
2
7
X
X'
TO S2 AND
VTVM VIDEO AMPL
R201
2,200
R203
470K
R206
75
C139
500
C140
.01
R208
10
R209
10
R202
750
R207
470
TO GRID
OF V34
NOTE:
UNLESS OTHERWISE SHOWN:
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UF.
MON VID OUTPUT
E8
P31
TM 689-277

Figure 185. Monitor video amplifier V33, simplified schematic diagram.

proportional to the peak voltage applied. Note that the polarity of this voltage is the same as that obtained when switch S5 is in the NEG PEAK position and a negative pulse is applied to the video amplifier input. Thus, the magnitude of a reading is obtained directly from the meter deflection; the sense of the reading is determined by the setting of S5.

6. A fixed +50-volt bias is applied to the peak detector output points (terminals 7 and 10 of TB13B). This voltage is derived from a voltage-divider network consisting of R187 and R186 connected to the +250-volt supply. This bias is applied also to the grid of either V32A or V32B, depending on the position of S5. An equal bias is applied to the other V32 grid by the voltage-dividing network of R192, R196, and R199 or R195, R198, and R200, which is also connected to the +250-volt supply. If switch S5 is in the NEG PEAK position, for example, fixed bias is applied to the grid of V32A from terminal 7. In this same setting of S5, however, a voltage is applied from the R195, R198, and R200 voltage divider to the grid of V32B. This is adjusted to be ex-

actly equal to that applied to the grid of V32A. This adjustment is made for a zero reading on the meter. The 50-volt bias for both tubes is derived from the same source; therefore, individual adjustment of R196 and R198 can be made to compensate for variations in individual tubes and other components.

Note. For Radio Transmitter T-303/G on Order No. 1640–Phila–51 (serial No. 57–297) and Order No. 15739–Phila–55 (serial No. 298–417), the +50-volt fixed bias is increased to +60 volts because of the change in the value of R186 from 220K ohms to 270K ohms. The value of this resistor was changed to center the zero balance potentiometer adjustments.

(3) *Monitor video amplifier V33* (fig. 185). The monitor amplifier is a 1-stage, cathode follower used to match the video output from the if. amplifier to the 50-ohm terminating impedance of the VID MON OUTPUT coaxial cable. The monitor video input voltage is applied through coupling capacitor C136 and parasitic suppressor R204 to the grid of V33, a 6AG7 pentode. Resistors R201 and R202 form a voltage divider to provide proper input level to the vtvm video amplifier. The output voltage developed across cathode load resistors R206 and R207 is coupled to VID MON OUTPUT jack P31 and to the grid of V34 in parallel. Capacitor C139 is an electrolytic capacitor that provides the low-frequency response. Capacitor C140 is a paper capacitor across C139 to balance out the inductance in C139. Resistors R208 and R209 are for parasitic suppression. With this circuit, the frequency response of this stage is flat from 30 cps to about 6 mc within ± 0.5 db.

(4) *Order-wire monitor circuits* (fig. 186).

(*a*) *General.* The order-wire monitor provides an indication of the presence or absence of the order-wire carrier in the main rf channel. The presence of this order-wire signal indicates that the transmitter is functioning properly, because this is the only signal that is present at all times. The lack of order-wire carrier initiates an order-wire alarm signal and indicates transmitter failure. If this occurs and standby equipment and transfer control facilities are available, the order-wire alarm signal actuates the transfer control equipment, which automatically replaces the defective transmitter with the standby transmitter.

(*b*) *Monitor order-wire amplifier V34.* The output of the monitor video amplifier is coupled through capacitor C142 to the grid of order-wire monitor amplifier V34, a 5654/6AK5W pentode. This signal contains both video and 6-mc components. The resonant circuit, L31–C144, in the plate circuit of V34, however, is tuned to 6 mc, thus amplifying the 6-mc component and rejecting the video component. Consequently, the output of this stage contains only the 6-mc order-wire signal. Capacitors C143 and C145 in this stage are video and 6-mc bypass capacitors. Resistor R210 is the grid resistor, R211 the cathode-biasing resistor, and R212 the plate and screen-dropping resistor.

(*c*) *Monitor order-wire detector-voltage doubler V35.* The amplified 6-mc signal then is fed to V35, a 6AL5W twin diode, connected as a voltage doubler. During the negative half-cycle of the input voltage, V35A conducts and charges capacitor C146 to a voltage equal to the peak amplitude of the applied signal. Consequently, a positive voltage is developed across C146, almost equal to the peak applied voltage. During the next positive half-cycle of the input voltage, the voltage that exists across C146 adds to the value of the applied voltage, so that C147 in the cathode circuit of V35B is charged up to twice the peak voltage (fig. 187). The resulting output voltage

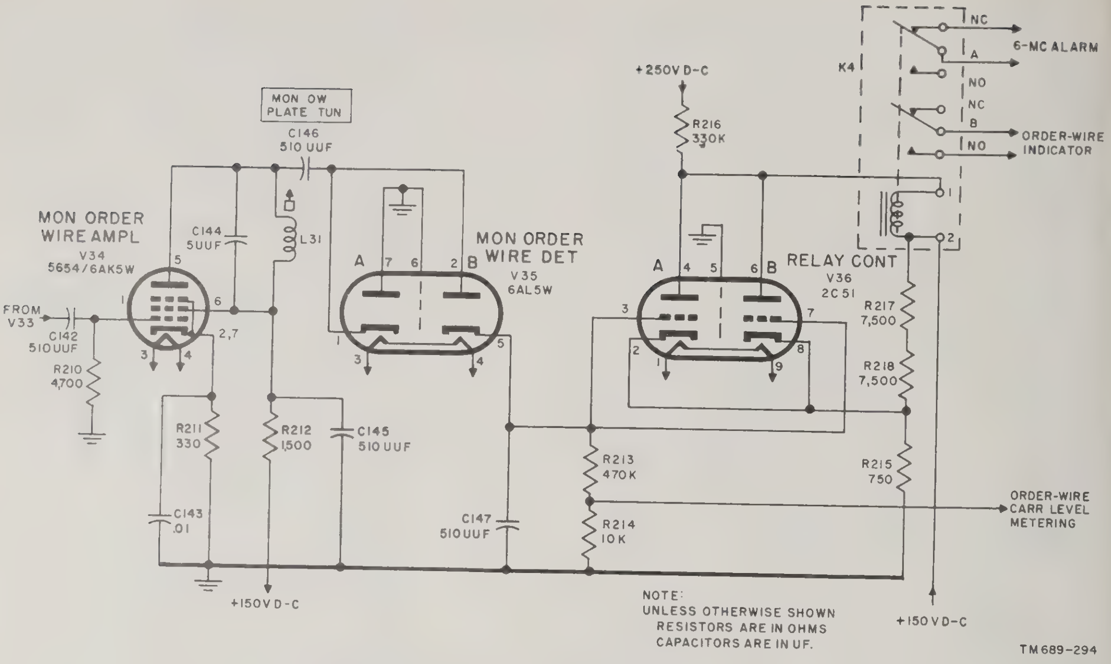

MON OW PLATE TUN
C146 510 UUF
MON ORDER WIRE AMPL
V34 5654/6AK5W
C144 5UUF
L31
MON ORDER WIRE DET
V35 6AL5W
+250V D-C
R216 330K
K4
NC
A
NO
NC
B
NO
6-MC ALARM
ORDER-WIRE INDICATOR
RELAY CONT
V36 2C51
A
B
R217 7,500
R218 7,500
R215 750
FROM V33
C142 510UUF
R210 4,700
R211 330
R212 1,500
C145 510 UUF
C143 .01
+150V D-C
C147 510UUF
R213 470K
R214 10K
ORDER-WIRE CARR LEVEL METERING
NOTE: UNLESS OTHERWISE SHOWN RESISTORS ARE IN OHMS CAPACITORS ARE IN UF.
+150 V D-C
TM689-294

Figure 186. Order-wire monitor amplifier V34, detector-voltage doubler V35.

developed across the RC network of C147, R213, and R214 is a dc voltage, the amplitude of which is equal to approximately twice the amplitude of the 6-mc signal originally obtained across the plate circuit of V34. A portion of this voltage is fed to the meter circuit to provide an indication of its magnitude.

(*d*) *Relay control circuit V36.* Tube V36, a 2C51 twin triode with both sections connected in parallel, normally is biased to cutoff in the absence of an input signal, because of the fixed voltage of about 7 to 8 volts applied to the cathode from the +150-volt dc supply, through voltage divider R217, R218, and R215. Resistor R216 is a current-limiting resistor in series with the +250-volt, dc supply and the coil of relay K4, which establishes a biasing current through the coil. This sensitive relay is in the plate circuit of V36, and operates when the relay current is about 2.5 ma. The bias current opposes the direction of flow of the normal tube current through the coil of K4, so that more than 2.5 ma must flow through the tube to operate the relay. This places the relay operating point on a more linear portion of the tube characteristic curve. With a normal order-wire signal, the positive dc voltage applied to the grid of this stage is sufficient to maintain the relay operated at all times, because the tube current exceeds the relay bias current by more than 2.5 ma. In this condition, 115-volt ac power is applied to TRANSMITTER OPERATING lamp I 1 on the meter panel from terminal 5 of TB13B (which is connected to the 115-volt line) through contacts B of K4, terminal 4 of TB13B, terminal M of J13, through I 1, terminal P of J13 to the common side of the 115-volt line. While this condition exists, the TRANSMITTER OPERATING lamp remains lighted. At the same time, contacts A of K4, which control the external order-wire alarm circuit, remain open. These are connected through terminals 4 and 5 of TB13B to terminals 2 and 3 of TB4A and to J3 on the order-wire transmitter. If the order-wire carrier disappears, V36 is cut off, the relay opens, the TRANSMITTER OPERATING lamp is extinguished, and the contacts are closed to J3, controlling operation of the transfer control equipment.

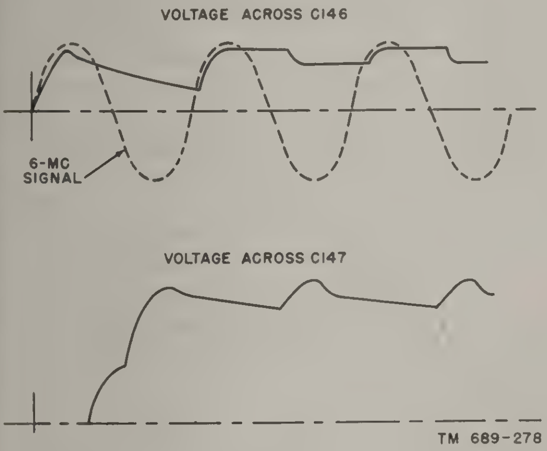


Figure 187. Order-wire monitor, peak detector waveforms.

168. External Monitoring Facilities

a. General. In addition to the many monitoring and measuring facilities that are an integral part of the equipment, certain signals are available at external connection points. These signals may be used in connection with equipment that is not a part of Radio Transmitter T–303/G to effect supplementary control and monitoring functions. The signals include the dc afc monitoring voltage and the order-wire carrier alarm signal. Both of the signals appear on pins of jack J3 which, although electrically unrelated, is placed on the order-wire transmitter chassis for mechanical convenience and ease of access. These two signals are used in the operation of the transfer control equipment.

b. Afc Monitoring Signal. The dc afc monitoring signal is taken from the if. discriminator output at the same point in the circuit from which the afc voltage to the chopper is taken. Its measurement gives an indication proportional to the dc afc voltage, which is an error signal whose level varies in accordance with the amount by which the klystron is off-frequency. The signal is brought to terminal 2 of TB11 on the if. chassis and then it goes through terminal 4 of TB4 on the transmitter chassis to terminal 3 of TB1 on the order-wire transmitter. The signal is not used in the order-wire transmitter but appears at pin F of J3 on this chassis, where it may be obtained for external use.

c. Order-wire Carrier Alarm Signal. The two leads for the order-wire carrier alarm signal are connected to a pair of normally closed relay contacts on K4. Relay K4 also controls the TRANSMITTER OPERATING indicator lamp on the meter panel. Because the relay is energized under normal operating conditions, the contacts are open most of the time. When the order-wire carrier is absent, these contacts close, because of the action in the relay control tube at the output of the order-wire monitor circuits. The order-wire carrier alarm leads from contacts A on K4 appear at terminals 2 and 3 of TB13 on the vtvm and order-wire monitor subchassis. The signal travels from there through terminals 2 and 3 of TB4 on the transmitter chassis to terminals 1 and 2 of TB1 on the order-wire transmitter chassis. The order-wire carrier alarm signal is not used in the order-wire transmitter chassis, but appears on pins J and H of J3 on that chassis.

169. Meter Panel
(fig. 408)

a. General.

(1) All metering circuits in the radio transmitter, primary POWER circuit breaker CB1, and TRANSMITTER OPERATING lamp I 1 are located on the meter panel subchassis. METER A, M2 (at the extreme left), meters the circuits indicated and controlled by switch S4; PEAK VTVM meter M4 operates in conjunction with the vtvm circuit and measures video signals (positive or negative, depending on the setting of POS PEAK–NEG PEAK switch S5) selected by the VTVM SEL

SW S2. LINE VOLTS meter M3 indicates the voltage of the 115-volt, ac line; METER B, M1 (at the extreme right), meters circuits indicated and controlled by switch S3. Details of the circuitry at the originating point of each of the metered circuits are given in the description of that circuit.

(2) Generally, voltage measurement is made in the meter circuit by connecting a suitable voltage-dividing meter multiplier resistor network to the point at which the voltage is measured. Current measurements are made by inserting a small series resistor in the circuit being metered and applying the voltage developed across this resistor to the meter.

(3) Pertinent information for meters M2 and M1 is tabulated in *b* and *c* below. Each chart includes eight columns that contain the following information:

(*a*) *S4 (or S3) pos* column indicates the position of the meter switch.

(*b*) *Pos name* column indicates the front panel marking corresponding to the switch positions indicated in the switch position column.

(*c*) *Circuit monitored* column indicates the stage being monitored, and the subassembly on which it is located is listed in parentheses.

(*d*) *Normal range* column indicates the meter reading range that should be obtained when equipment is operating properly.

(*e*) *TB on meter panel* column indicates the terminal number and terminal board number on the meter panel feeding voltage to the meter circuit.

(*f*) *TB on subassembly* indicates the terminal number and terminal board number on the subassembly feeding voltage to the meter panel terminal board.

(*g*) *Resistors on meter panel* column indicates the meter resistors located on the meter panel.

(*h*) *Resistors on subassembly* column indicates the meter resistors on subassembly of stage being monitored.

b. METER A, M2. The chart given below lists functional data for METER A, M2.

S4 Pos	Pos name	Circuit monitored	Normal range	TB on meter panel	TB on subassembly	Resistors on meter panel	Resistors on subassembly
1	AFC 1ST MULT GRID	V11B (crystal mult)	50–130	C, P29	3, TB10B	R241	R81 R82
2	AFC MIXER	CR1 (crystal mult).	35–65	E, P29	3, TB11B	R243, R246	R87 R89
3	KLYSTRON POWER OUT.	V38 (main chassis).	30–150	D, P29	1, TB7	R251, R244	
4	PA CATH CUR	V37 (main chassis).	100 (absolute max = 125)	M and F, P29.	5 and 6, TB6 (via R255).	R255, R245	
5	1ST LIM GRID	V19 (if. amp)	20 (min)	H, P29	4, TB11B	R249	R113
6	AFC CORRECTION+ and AFC CORRECTION−.	V21 (if. amp)	0, ±5 (average).	L, P29	------------	R247, R248	R130
7	REFL V	V8, V9, V10 (evr).	70–100	J, P29	9, TB9 to 5, TB5.	R239, R240, R242	R54, R55, R56
8	BEAM	−1,000-volt output of high voltage power supply.	95–105	K, P29	1, TB1 to 14, TB5 to 6, TB5.	R236, R237, R238	R22, R23, R24

c. METER B, M1. The chart given below lists functional data for METER B, M1.

S3 Pos	Pos name	Circuit monitored	Normal range	TB on meter panel	TB on subassembly	Resistors on meter panel	Resistors on subassembly
1	AFC 2D MULT GRID	V12 (crystal mult).	30–70	BB, P29	2, TB10	R221	R84, R85
2	WAVEMETER	Wavemeter (main chassis).	20–100	S, P29	P21	R222	R251
3	PA GRID CUR.	V37 (main chassis).	40–100	V, P29	(Junction of R257, R258).	R230	R256
4	PA POWER OUT	V37 (main chassis).	40–150	DD, P29	1, TB8	R223	
5	ORDER WIRE CARR LEVEL.	V35 (vtvm)	50–80	T, P29	20, TB13		R213
6	PA PLATE V	V37 (main chassis).	50–150 when PA CATH CUR =100.	Y, P29	(R254)	R231, R232, R235.	
7	+300V	+300-volt supply in low voltage power supply.	95–105	W, P29	1, TB2	R229, R233, R234.	
8	+250V	+250-volt supply in low voltage power supply.	95–105	Z, P29	2, TB2 to 11, TB13.	R226, R233, R234.	
9	+150V	+150-volt supply in low voltage power supply.	95–105	X, P29	3, TB2 to 8, TB11 to 6, TB13 to 1, TB10 to 2, TB12.	R225, R227.	
10	−150V	−150-volt supply in low voltage power supply.	95–105	CC, P29	4, TB4	R219, R220.	

d. PEAK VTVM Meter, M4. The circuit operation of PEAK VTVM meter and its associated switch has been covered fully in the description of the circuit (par. 167).

e. LINE VOLTS Meter, M3. LINE VOLTS meter M3 measures the voltage applied to Power Supply PP–764/G.

170. Electronic Voltage Regulator

a. General. The electronic voltage regulator (evr) is part of the power supply system for the radio transmitter. It takes an unregulated floating voltage of 1,350 volts dc, obtained from Power Supply PP–764/G, and furnishes to the klystron reflector a highly stable, low-ripple regulated dc voltage, continuously adjustable between —1,295 and —2,000 volts, with respect to ground (or between —295 and —1,000 volts, with respect to the klystron beam voltage). A well-regulated voltage of —1,000 volts dc is furnished to the unit as a reference voltage.

b. Functional Description (fig. 188).

(1) The evr contains components and circuitry similar to those of most conventional, degenerative-type series voltage regulator circuits. An unregulated floating voltage (not tied to any fixed reference) of 1,350 volts dc is applied

through regulator tube V8, which acts as a variable series resistance. The conduction of the regulator tube is controlled by dc control amplifier V9, the cathode of which is connected to voltage reference tube V10. Voltage changes are transmitted to the control amplifier grid through a portion of the voltage divider across the output. This sets the plate voltage of V9 which, by its interconnection, sets the grid voltage of V8 so that the output voltage is caused to return to its desired value.

(2) Instead of taking the output voltage from the cathode of regulator tube V8, this point is connected to the —1,000-volt klystron beam supply, which is used as a fixed reference level for the evr. Likewise, the voltage from the lower end of voltage reference tube V10 is used in this application to tie to the output divider. The output is obtained from the arm of a potentiometer physically located on the radio transmitter chassis and connected between the cathode of V10 and the negative side of the dc input voltage supply. The functional position of the evr in relation to the other dc power sources for the klystron is shown on figure 154. Considering the differences explained herein, the operation of the circuit can be analyzed in a manner similar to that of a conventional voltage regulator circuit.

c. Detailed Circuit Description (fig. 409).

(1) *Circuit arrangement.*

(*a*) Regulator tube V8, a type 807, is operated with its plate connected through parasitic-suppressor resistor R60 to the most positive (or least negative) side of the 1,350-volt input supply (approximately —650 volts) from terminal 1 of TB9. The cathode is connected to the —1,000-volt klystron beam supply through terminal 2 of TB9. The

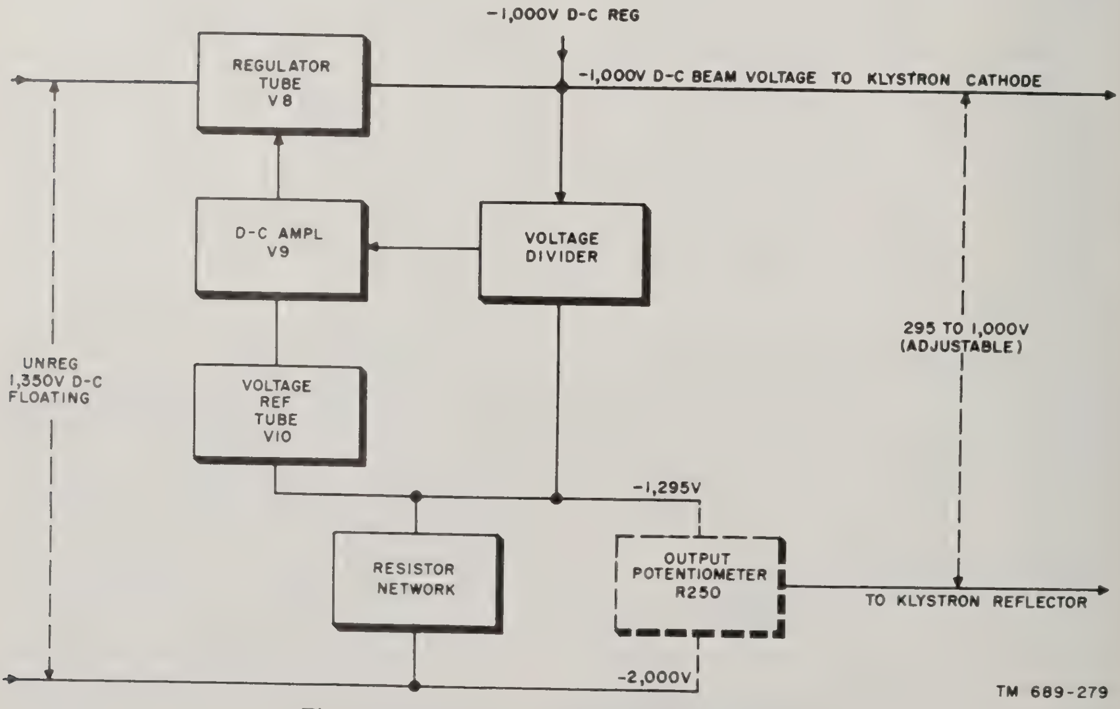

-1,000V D-C REG
-1,000V D-C BEAM VOLTAGE TO KLYSTRON CATHODE
REGULATOR TUBE V8
D-C AMPL V9
VOLTAGE DIVIDER
VOLTAGE REF TUBE V10
UNREG 1,350V D-C FLOATING
295 TO 1,000V (ADJUSTABLE)
-1,295V
RESISTOR NETWORK
OUTPUT POTENTIOMETER R250
TO KLYSTRON REFLECTOR
-2,000V
TM 689-279

Figure 188. Electronic voltage regulator, functional block diagram.

—1,000-volt regulated supply is used to tie the regulated output to a fixed reference level. The screen grid is connected to the —650-volt point through parasitic-suppressor resistor R57. The control grid voltage for V8 is obtained from the plate of dc control amplifier V9 through isolating resistor R58. The series resistance and, therefore, the voltage drop across this tube are functions of the dc voltage applied to its grid by the dc control amplifier.

(*b*) The plate supply voltage for V9 is obtained from the —1,000-volt reference line through plate-load resistor R61. The cathode is connected to the plate of voltage reference tube V10. Resistors R62 and R69, R63 and R70, and R64 and tube V10 are in series. Resistors R71, R72, and R73 are also in series. These two series strings are in parallel with each other, and the whole combination, which is in series with resistors R65 through R68, forms a voltage-divider network across a portion of the output of the supply. A tap in this series provides the screen-grid voltage for V9. Voltage for the V9 control grid is obtained from the arm of potentiometer R72. This potentiometer is adjusted to set the operating point of V9 and the desired output voltage. Capacitors C31 and C32 minimize the effects of transient voltage variations on the cathode voltage of V9. Capacitor C33 improves the regulation of the supply against ripple and sharp transient voltage variations.

(*c*) The lower end of resistor R68 in the output divider network and bleeder is connected to the most negative side of the 1,350-volt input supply (—2,000 volts). REFL VOLTS ADJ potentiometer R250 in the transmitter main chassis (fig. 402) is connected to terminals 5 and 6 of TB9, placing it in parallel with R65 through R68. Terminal 5 is connected to a point on the output divider network, placing it about 700 volts higher than the —2,000-volt point at terminal 6. Thus, the potentiometer arm can be used to select any desired reflector voltage between —1,295 and —2,000 volts dc with respect to ground.

(*d*) To reduce the heater-cathode voltage difference in V8 and V9, a voltage divider consisting of R74 through R77 is connected between the —1,000- and —2,000-volt points. A tap on this divider is connected to the heater circuit to insure that the filament-cathode voltage difference is within specifications.

(2) *Circuit operation.* Assume that the input voltage increases (that is, becomes more than 1,350 volts). This change is reflected across the output voltage-divider network and causes a rise in the grid voltage of V9 with respect to cathode. The increased current, which then flows through V9, causes a larger drop across load resistor R61, which results in a reduced plate voltage on V9 and, consequently, a lower grid voltage for V8. This increases the series (plate-cathode) resistance of V8, causing a larger voltage drop across the tube. The circuit values are so chosen that this increased drop exactly compensates for the voltage rise at the input. If there is a decrease in the input voltage, the reverse action takes place. The entire voltage change is compensated for by the change in drop across V8. This maintains a constant 1,000-volt difference between the —1,000-volt reference level and the —2,000-volt point at terminal 6 of TB9. Consequently, the tapped voltage at terminal 5 of TB9 also is maintained at a constant level.

171. Order-Wire Transmitter T–389/TRC–29

a. General. The order-wire transmitter generates a 6-mc carrier that can be frequency modulated by either the through or local audio signal. The through audio signal is obtained from the order-wire receiver which receives it from the preceding Radio Set AN/TRC–29 in the radio relay system. The local audio signal is furnished by either a handset at the transmitter location or a remote handset located nearby. The local and through audio signals can be mixed in the order-wire transmitter and transmitted as a composite signal. The through order-wire signal may contain audio information from any or all of the other stations or terminal on the relay route (in the same direction of transmission); therefore, communication is carried on by means of the order-wire transmitter (and receiver) on a party line basis. On–off carrier-keying facilities are provided which are used for both signaling and alarm purposes. The modulated 6-mc order-wire transmitter output is fed to the modulator of Radio Transmitter T–303/G (pars. 161*c* and 164*a*) where it modulates the main transmitter carrier and is transmitted together with the regular 23-channel multiplexed traffic. An afc system is provided for holding the 6-mc carrier on frequency. Also included on this chassis are a 1-kc test-tone oscillator for audio testing, a monitor audio amplifier for checking audio level and percent modulation, a meter circuit, a test switch circuit, and a connector for connecting the system to transfer control equipment.

b. Block Diagram Description (fig. 189 and 410).

(1) *Order-wire carrier signal circuits.* Audio signals from both through and local sources are passed through ORDER WIRE TEST SWITCH S1 and applied to V1, a type 2C51 twin-triode audio amplifier. The through signal is applied to the grid of one triode section and the local signal to the grid of the other. Each audio level may be set independently with a potentiometer in its grid circuit. The amplified audio signals are mixed in the primary of coupling transformer T1, which acts as the common load for the V1 plates. The circuit of carrier oscillator V2, a type 5725/6AS6W, is arranged so that oscillations at approximately 6-mc are supported between the control grid and plate of the tube. Audio modulating signals from the secondary of T1 are applied to the suppressor grid of the tube, where they frequency modulate the 6-mc carrier by changing the tube resistance in conformance with the modulating voltage. The modulated 6-mc signal is fixed in amplitude level by carrier limiter V3, a 5654/6AK5W. The carrier limiter output is fed through the ORDER WIRE CARR LEVEL potentiometer to carrier amplifier V4, a 5725/6AS6W. The suppressor grid of V4 is connected to an external keying circuit, which permits the carrier to be keyed off for signaling and alarm purposes. The output of V4 is sent to the main transmitter where it is used to modulate the main transmitter carrier.

(2) *Afc system.* A portion of the modulated 6-mc signal is obtained inductively, by transformer T3, following the carrier-limiter stage. This signal is passed through afc limiter V8, a 5654/6AK5W, which further reduces any remaining amplitude variations. The output of V8 is applied through transformer T2 to afc discriminator V7, a 6AL5W twin diode. Part of the discriminator output passes through a filter that removes all but the dc afc signal components, which are sent through S1 to afc amplifier V6A, one-half of a 2C51 twin triode. The output of V6A is a dc signal, the magnitude of which is determined by the amount and direction of error of the carrier signal with respect to its assigned frequency. This voltage is applied to the suppressor grid of carrier oscillator V2, where it brings the oscillator frequency back to the correct value.

(3) *Monitor audio amplifier.* The remainder of the discriminator output passes through another filter. This removes all but the audio modulation voltage, which is sent through V6B (the other half of the 2C51 twin triode), ORDER WIRE TEST SWITCH S1, and meter selector switch S2, to the meter, where its value is read in terms of percent modulation.

(4) *Tone oscillator.* The tone oscillator stage uses a 5654/6AK5W tube, V5, in a phase-shift oscillator circuit, arranged to develop a 1,000-cps signal at

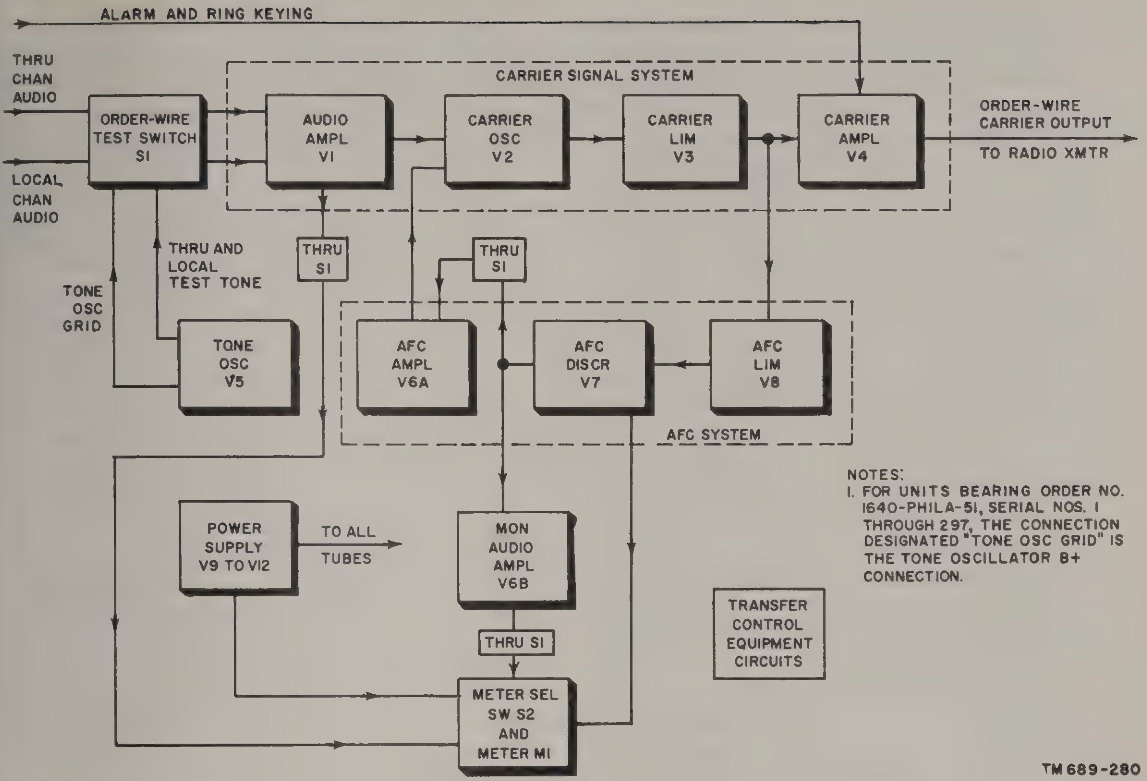

ALARM AND RING KEYING
THRU CHAN AUDIO
LOCAL CHAN AUDIO
ORDER-WIRE TEST SWITCH S1
CARRIER SIGNAL SYSTEM
AUDIO AMPL V1
CARRIER OSC V2
CARRIER LIM V3
CARRIER AMPL V4
ORDER-WIRE CARRIER OUTPUT
TO RADIO XMTR
THRU AND LOCAL TEST TONE
TONE OSC GRID
THRU S1
THRU S1
TONE OSC V5
AFC AMPL V6A
AFC DISCR V7
AFC LIM V8
AFC SYSTEM
NOTES:
1. FOR UNITS BEARING ORDER NO. 1640-PHILA-51, SERIAL NOS. 1 THROUGH 297, THE CONNECTION DESIGNATED "TONE OSC GRID" IS THE TONE OSCILLATOR B+ CONNECTION.
POWER SUPPLY V9 TO V12
TO ALL TUBES
MON AUDIO AMPL V6B
TRANSFER CONTROL EQUIPMENT CIRCUITS
THRU S1
METER SEL SW S2 AND METER M1
TM 689-280

Figure 189. Order-Wire Transmitter T–389/TRC–29, block diagram.

a level about ¾ volt. When the ORDER WIRE TEST SWITCH is in either TONE position, plate voltage is supplied to the tone oscillator tube, and the oscillator furnishes the 1,000-cps voltage. This is sent to the ORDER WIRE TEST SWITCH, which connects it to either the through or local audio amplifier input for test purposes.

Note. For Order-Wire Transmitter T–389/TRC–29 on Order No. 15739–Phila–55 (serial No. 298–417), the plate and screen of the tone oscillator are connected directly to the B+ line so that B+ is always present at these points. The tone oscillator is disabled by grounding the phase-shift network in the grid circuit of V5. Therefore, when the ORDER WIRE TEST SWITCH is in either TONE position the phase-shift network is disconnected from ground and the tone oscillator operates normally.

(5) *Power supply.* A voltage-regulated power supply is used in the order-wire transmitter. It furnishes an output voltage of +140 volts dc. Full-wave rectifier V9, a 6X4W, supplies dc to 6AS7G series regulator tube V10B. The resistance and output voltage of V10B is controlled by dc amplifier V12, a 6AU6 pentode. Input or output voltage fluctuations are reflected as voltage variations at the grid of V12, which amplifies them and changes the grid voltage of V10B to bring the output voltage back to its proper value. Tube V10A, the other half of the 6AS7G, is connected as a rectifier. This rectifier, with voltage reference tube V11, and OB2, furnishes a voltage that is used to stabilize the steady-state biasing conditions on dc amplifier V12.

(6) *Order-wire test switch circuit.* ORDER WIRE TEST SWITCH S1 is used in conjunction with many of the circuits within the order-wire trans-

mitter and controls its overall functions. Position 1 disables the afc system. Position 2 is used for normal operation. Position 3 changes the audio input to the meter so that it reads input audio level instead of percent modulation. Position 4 applies test tone to the through channel audio amplifier. Position 5 applies test tone to the local channel audio amplifier.

(7) *Metering circuits.* Meter M1 measures a number of different quantities and is controlled by meter selector switch S2. In position 1, the carrier-limiter grid bias voltage is measured. Positions 2 and 3 display readings of the dc discriminator voltages. Position 4 measures the audio signal in terms of either level or percent modulation, depending on the position of switch S1. Position 5 of the switch monitors the voltage output of the regulated power supply.

(8) *Transfer control equipment circuits.* Though not a functional part of the order-wire transmitter, facilities are mounted on the chassis for the connection to transfer control equipment of order-wire carrier alarm and afc monitor signals from the main transmitter, as well as other voltages necessary for transfer control operation.

c. Detailed Circuit Description.

(1) *Order-wire carrier signal.*

(*a*) *Input circuit and audio amplifier V1* (fig. 190).

1. Audio amplifier V1 uses a type 2C51 twin triode. The grids of the two sections are fed from separate sources, and the plates are connected in parallel.

2. The local audio signal is fed across AUDIO LEVEL LOCAL INPUT potentiometer R2 from pin D of J1 and section 1 of ORDER WIRE TEST SWITCH S1 ((6) below). The desired signal level that determines the level of frequency modulation is obtained from the arm of R2 and fed to the grid to one section of V1. The amplified output of V1 is developed across the primary of audio coupling transformer T1.

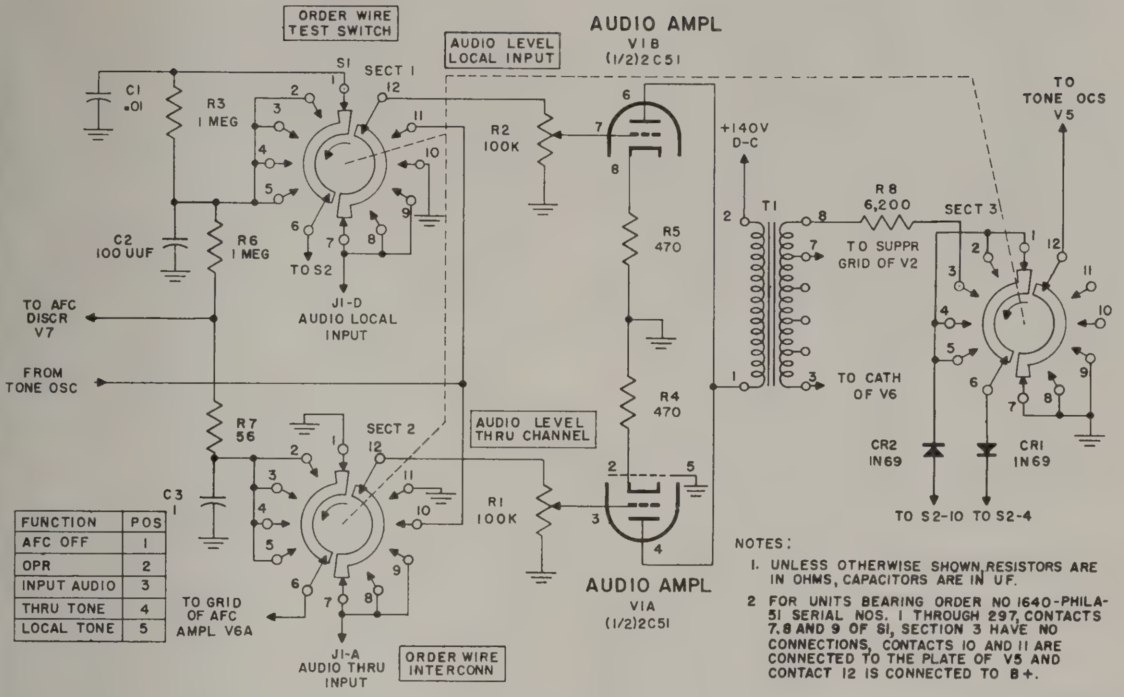
3. The through audio signal is fed across AUDIO LEVEL THRU CHANNEL potentiometer R1 from pin A of J1 and section 2 of ORDER WIRE TEST SWITCH S1. The desired signal level that determines the level of frequency modulation is obtained from the arm of R1 and fed to the grid of the other section of V1. The amplified output of this half of V1 also is developed across the primary of T1 and, in this manner, the two audio signals are mixed.

4. The audio levels are adjusted by potentiometers R1 and R2 to obtain 100 percent modulation of the order-wire carrier signal. The primary of T1 serves as the plate load for the tube. Resistors R4 and R5 are the cathode load resistors for the two tube sections, and the two potentiometers serve as grid loads.

(*b*) *Carrier oscillator V2* (fig. 191).

1. Carrier-oscillator tube V2 is a 5725/6AS6W pentode. Consider first its operation with no modulating signal present. A portion of the voltage developed across inductor L1 in the plate circuit of V2 is fed back to its grid through feedback capacitor C7. This feedback is regenerative and large enough to maintain oscillation in the circuit. The circuit parameters are chosen to obtain an oscillation frequency of 6 mc.

2. The carrier-oscillator frequency can be controlled by varying either the reactance of L1 or the plate resistance of the tube. With no audio modulation present, the circuit is tuned to 6 mc by FREQ ADJ control L1. The 6-mc frequency then is maintained by the afc system, which controls the tube resistance, and hence, by the plate current flow, by an afc bias


ORDER WIRE TEST SWITCH
AUDIO LEVEL LOCAL INPUT
AUDIO AMPL
V1B
(1/2)2C51
S1
SECT 1
C1
.01
R3
1 MEG
R2
100K
+140V D-C
TO TONE OCS V5
T1
R8
6,200
SECT 3
C2
100 UUF
R6
1 MEG
TO S2
R5
470
TO SUPPR GRID OF V2
J1-D
AUDIO LOCAL INPUT
TO AFC DISCR V7
FROM TONE OSC
TO CATH OF V6
R4
470
R7
56
SECT 2
AUDIO LEVEL THRU CHANNEL
CR2
1N69
CR1
1N69
C3
1
R1
100K
TO S2-10
TO S2-4
AUDIO AMPL
V1A
(1/2)2C51
TO GRID OF AFC AMPL V6A
J1-A
AUDIO THRU INPUT
ORDER WIRE INTERCONN

FUNCTION	POS
AFC OFF	1
OPR	2
INPUT AUDIO	3
THRU TONE	4
LOCAL TONE	5

NOTES:

1. UNLESS OTHERWISE SHOWN, RESISTORS ARE IN OHMS, CAPACITORS ARE IN UF.
2. FOR UNITS BEARING ORDER NO 1640-PHILA-51 SERIAL NOS. 1 THROUGH 297, CONTACTS 7, 8 AND 9 OF S1, SECTION 3 HAVE NO CONNECTIONS, CONTACTS 10 AND 11 ARE CONNECTED TO THE PLATE OF V5 AND CONTACT 12 IS CONNECTED TO B+.

TM 689-295

Figure 190. Audio amplifier V1, simplified schematic diagram.

that is applied to the suppressor grid of V2.

3. The audio signals developed in the secondary of T1 also are applied to the suppressor grid of V2. Because the audio varies the voltage on the suppressor, the instantaneous frequency of oscillation changes directly with the amplitude of the modulating signal. Thus, the output of V2 is an fm 6-mc carrier.

4. The deviation sensitivity of V2, the frequency change that occurs for a given audio voltage, is a function of the cathode impedance of the stage. The greater the cathode impedance, the lower the sensitivity of the circuit. The cathode impedance is determined primarily by circuit L2–C8. Inductor L2, MOD SENS ADJ control, can be varied to control the sensitivity of this stage, and is adjusted to provide a deviation of ±50 kc for 100 percent modulation. Necessary rf bypassing is provided by capacitors C4, C5, C6, and C9. Resistor R10 is the screen-dropping resistor, R12 is the grid resistor, and R11 the cathode-biasing resistor.

(*c*) *Carrier limiter V3* (fig. 192).

1. Since the frequency shift in the carrier oscillator is caused by varying the tube current, the carrier-oscillator output is slightly amplitude modulated as well as frequency modulated. The primary function of the carrier limiter is to remove these amplitude variations and provide a constant amplitude output voltage.

2. The output of the carrier oscillator is fed through coupling capacitor C10 to the grid of carrier limiter V3, a type 5654/6AK5W pentode. Tube V3 is operated

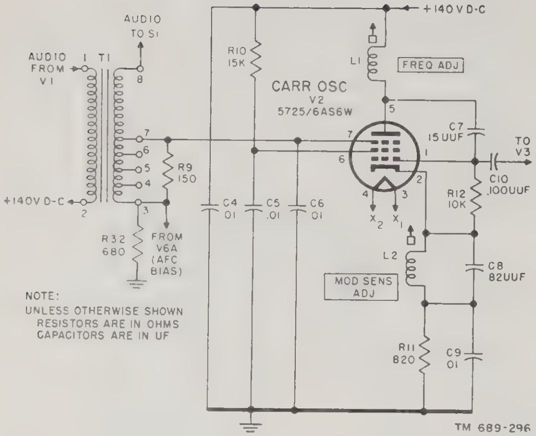

AUDIO
TO S1
AUDIO FROM V1
1
T1
8
7
6
5
4
+140V D-C
2
3
R9
150
R32
680
FROM V6A (AFC BIAS)
NOTE:
UNLESS OTHERWISE SHOWN
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UF
R10
15K
C4
01
C5
.01
C6
01
CARR OSC
V2
5725/6AS6W
+140V D-C
L1
FREQ ADJ
5
7
6
1
2
4
3
X_2
X_1
C7
15 UUF
TO V3
C10
.100UUF
R12
10K
L2
MOD SENS ADJ
C8
82UUF
R11
820
C9
01
TM 689-296

Figure 191. Carrier oscillator V2, simplified schematic diagram.

with the cathode grounded and the plate and screen connected through a common screen and plate voltage dropping resistor, R15, to the same dc potential. This stage uses a combination of saturation limiting and grid-cut-off limiting, which produces a flat-topped wave from a sine wave. Therefore, the signal applied to the grid is limited by the current saturation during the positive half-cycle and clipped during the negative half-cycle.

3. When the signal applied to the grid of V3 is positive, the grid draws current and a negative voltage is developed across R13. The RC circuit that consists of R13 and C10 maintains this bias at a level close to that of the peak value of the input signal by means of small amounts of grid current drawn on positive input peaks.

4. When the negative applied voltage drives the tube to cutoff, the plate voltage reaches its maximum value. Any further increase in input voltage in the negative direction is not amplified by the tube, and consequently a portion of the negative half-cycle would tend to be clipped by this stage. During the positive half of the input cycle, the low plate and screen voltage cause the tube to saturate at a relatively low signal level which tends to flatten the negative portion of the output signal.

5. This limited voltage appears

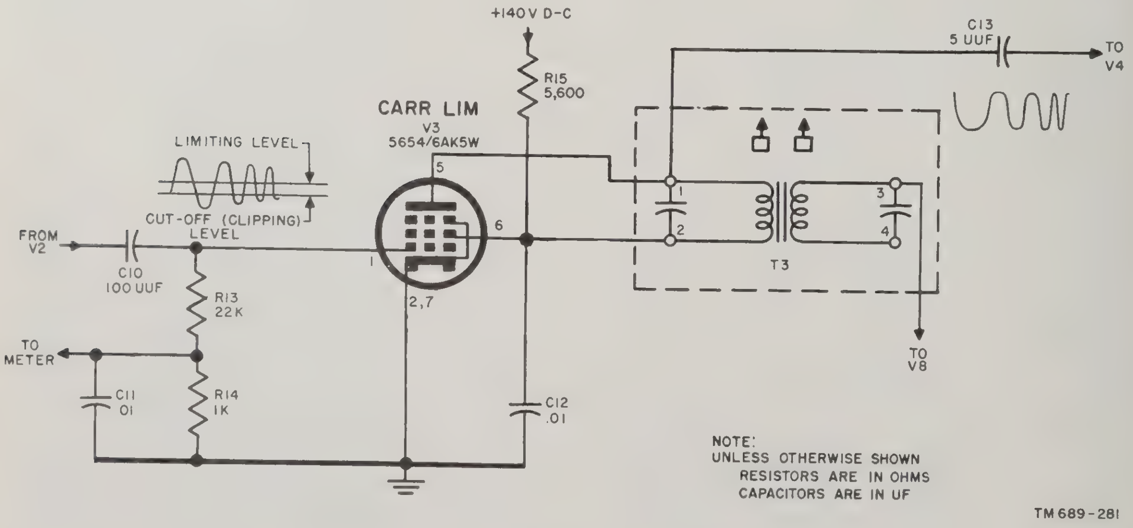

+140V D-C
R15
5,600
CARR LIM
V3
5654/6AK5W
LIMITING LEVEL
CUT-OFF (CLIPPING) LEVEL
FROM V2
C10
100 UUF
R13
22K
TO METER
C11
01
R14
1K
5
6
1
2,7
C12
.01
C13
5 UUF
TO V4
1
2
3
4
T3
TO V8
NOTE:
UNLESS OTHERWISE SHOWN
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UF
TM 689-281

Figure 192. Carrier limiter V3, simplified schematic diagram.

across the primary of T3, which is a wide-band, double-tuned transformer, in which the waveform is improved (rounded out), and the resultant constant amplitude fm carrier is fed to the carrier amplifier. Note that the secondary of T3 is not used in this circuit, but is used in the afc limiter. The primary of T3 acts as a plate load for V3. Suitable rf bypassing is provided by capacitor C12, while R13 is the grid resistor. Resistor R14 and capacitor C11 serve as a takeoff point for metering voltage.

(*d*) *Carrier amplifier V4* (fig. 193).

1. The output of V3 is coupled to carrier amplifier V4, a 5725/-6AS6W pentode, through C13 and ORDER WIRE CARR LEVEL potentiometer R16, which also serves as the grid resistor. The output of this stage, the level of which is adjusted by R16, is fed to the output connector of J2 through C15 and a length of RG–58C/U cable.

2. This stage can be keyed off by the application of a negative voltage, obtained from pin C of J1, to the suppressor grid of V4. In the absence of the negative voltage this stage acts as an amplifier. The application of about —12 volts cuts off the tube and no carrier output is obtained. Whenever the carrier is absent, a ringing (signaling) circuit is caused to operate at the receiving point. This feature also serves to operate the carrier alarm circuits, held open when the carrier is present.

3. Resistor R17 is the suppressor keying load resistor. Capacitors C36 and C13 act as a voltage divider to reduce the voltage fed to R16. Resistors R18 is the plate-load resistor and R19 the screen-dropping resistor. Capacitors C16 and C37 bypass the screen and plate, respectively. Bias voltage for the tube is built up across C14 and R20 in the cathode circuit.

(2) *Afc system.*

(*a*) *General.* To frequency modulate the carrier oscillator, its frequency must be sensitive to audio modulating voltage changes. This characteristic also makes it susceptible to undesirable changes in frequency. Consequently, since the oscillator is essentially free-running, an afc system is

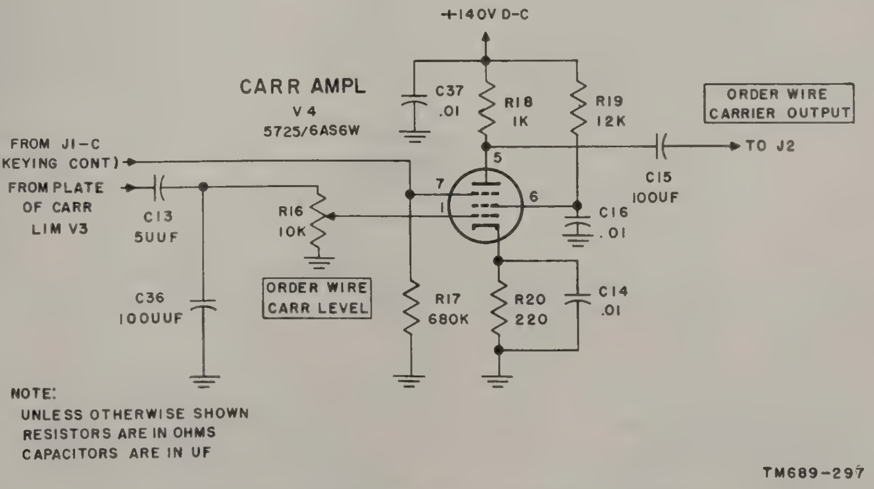
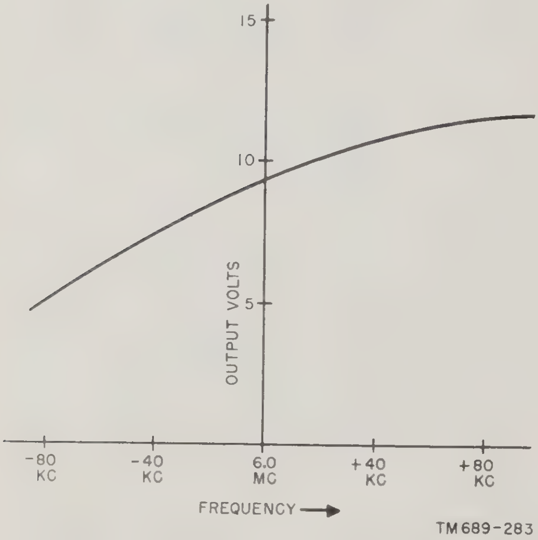

+140V D-C
CARR AMPL
V4
5725/6AS6W
C37
.01
R18
1K
R19
12K
ORDER WIRE
CARRIER OUTPUT
FROM J1-C
(KEYING CONT)
FROM PLATE
OF CARR
LIM V3
C13
5UUF
R16
10K
5
7
1
6
C15
100UF
TO J2
C16
.01
ORDER WIRE
CARR LEVEL
C36
100UUF
R17
680K
R20
220
C14
.01
NOTE:
UNLESS OTHERWISE SHOWN
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UF
TM689-297

Figure 193. Carrier amplifier V4, simplified schematic diagram.

required to stabilize the oscillator center frequency. The system used is based on the fact that the *average* value of the audio modulating signal is zero and the average, or center, carrier frequency will be some single controllable frequency; in this case, 6 mc. Any long-term deviation from this center frequency is an indication of oscillator frequency drift, and must be corrected. The afc circuit detects any long-term deviation from the center frequency and applies a corrective bias voltage to the oscillator circuit. This changes the oscillator frequency in the direction necessary to cancel the error.



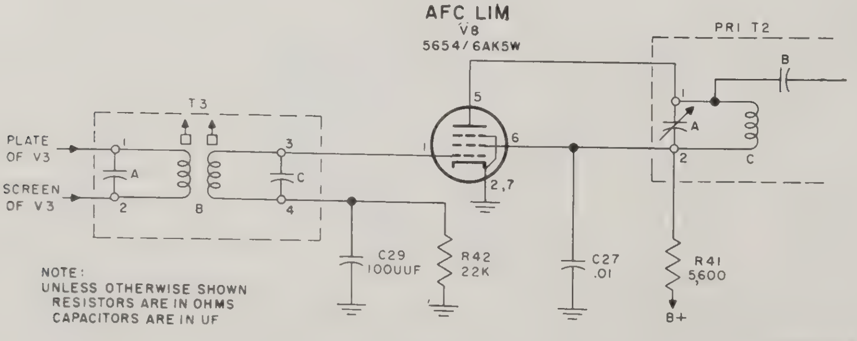
TM689-283

Figure 194. Transformer T3, response curve.

(*b*) *Afc limiter V8* (fig. 195). The output of carrier limiter V3 is applied to transformer T3. This transformer couples the signal from V3 to V8; its primary also acts as a load for V3. The transformer has the response characteristic shown on figure 194. As seen on this figure, the amplitude of the fm carrier at the secondary of the transformer varies considerably, depending on the instantaneous frequency. To obtain a constant amplitude voltage, it is necessary to use another limiter stage, V8, a type 5654/6AK5W. This stage is similar to carrier limiter V3. Its output is fed to the primary of T2. As in the carrier limiter, the cathode of afc limiter V8 is grounded. Bias voltage is developed across R42 and C29. Capacitor C27 bypasses the screen and R41 is the plate and screen voltage dropping resistor. For a further description of the operating principles of this circuit, refer to paragraph 166*c*(2) (*e*).

(*c*) *Afc discriminator V7* (fig. 196).

1. The afc discriminator is a type 6AL5W dual diode connected in a phase discriminator circuit. The output of the afc limiter, V8, is fed through T2 to this circuit. The 6-mc fm carrier is demodu-

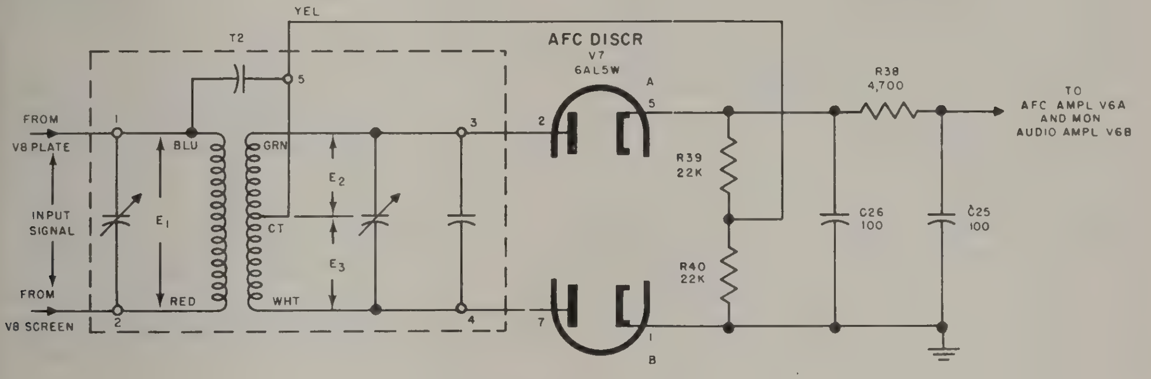


NOTE:
UNLESS OTHERWISE SHOWN
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UF

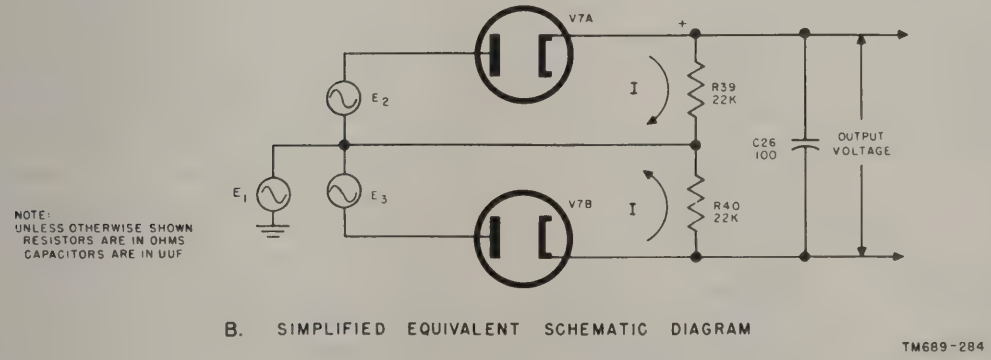
TM689-298

Figure 195. Afc limiter V8, simplified schematic diagram.

lated in this circuit and the output then consists of the original audio signal and a dc voltage, if the center frequency of the carrier oscillator is not at 6 mc. If the carrier is at 6 mc, the dc output is zero. If it is not, the dc output is positive or negative with respect to the reference level, depending on the direction of deviation; its magnitude is proportional to the amount of deviation.


YEL
T2
AFC DISCR
V7
6AL5W
A
5
R38
4,700
TO
AFC AMPL V6A
AND MON
AUDIO AMPL V6B
FROM
V8 PLATE
1
BLU
GRN
3
2
R39
22K
E2
INPUT
SIGNAL
E1
CT
C26
100
C25
100
E3
R40
22K
FROM
RED
WHT
V8 SCREEN
2
4
7
1
B

A. SCHEMATIC DIAGRAM


V7A
+
I
R39
22K
E2
C26
100
OUTPUT
VOLTAGE
E1
E3
V7B
I
R40
22K
NOTE:
UNLESS OTHERWISE SHOWN
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UUF
TM689-284

B. SIMPLIFIED EQUIVALENT SCHEMATIC DIAGRAM

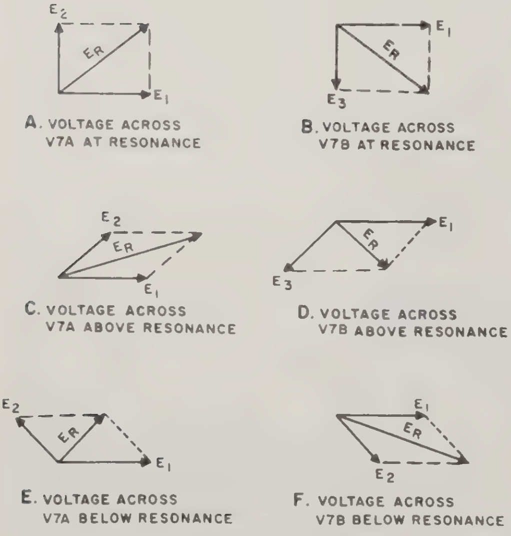
Figure 196. Discriminator V7, equivalent circuit and simplified schematic diagram.

2. The operation of the discriminator can be understood better with the aid of the simplified schematic and equivalent circuit diagrams on figure 196. The input voltage, E1, is developed across the primary of transformer T2, which is tuned to furnish maximum voltage at the intermediate frequency. This voltage is coupled to the center tap on the secondary of T2 through a capacitor that is part of the transformer. The secondary of T2 is tuned to the same frequency as the primary. The inductive coupling between the primary and secondary allows the magnetic flux in the primary to induce a current in the secondary. The voltage across the secondary caused by this current is 90° electrically out of phase with the primary voltage. This is due to the fact that, when the secondary of

a transformer is tuned to the same frequency, there is a 90° phase difference between the primary and secondary voltages at the resonant frequency.

3. Because of the center-tapped winding, the voltage across the secondary is split into two equal parts that are 180° out of phase with each other so far as the diode rectifiers (V7) are concerned. These voltages are designated E_2 and E_3. The relationship between these voltages and E_1 at the resonant frequency is shown vectorially in A and B, figure 197. Because of these conditions, the voltage across one diode is the vector sum of E_1 and E_2, while the voltage across the other diode is the vector sum of E_1 and E_3. The connection between the center tap of the T2 secondary and the junction of diode load resistors R39 and R40 forms the dc return for the balanced diode circuits.

4. The diode currents that flow through the load resistors oppose each other, building up output voltages of opposite polarities, as indicated on the equivalent circuit diagram. When the input frequency is the resonant frequency of T2, equal voltages are applied to each diode (V7A and V7B) and equal currents flow through R39 and R40. Since these currents flow in opposite directions, voltages equal in magnitude but opposite in polarity are developed across R39 and R40. The net voltage across the output circuit, therefore, is zero. Any rf at cathode of V7A is bypassed by capacitor C26.



A. VOLTAGE ACROSS V7A AT RESONANCE

B. VOLTAGE ACROSS V7B AT RESONANCE

C. VOLTAGE ACROSS V7A ABOVE RESONANCE

D. VOLTAGE ACROSS V7B ABOVE RESONANCE

E. VOLTAGE ACROSS V7A BELOW RESONANCE

F. VOLTAGE ACROSS V7B BELOW RESONANCE

Figure 197. Discriminator vector diagrams.

5. If the frequency of the input signal is above resonance, the secondary of T2 is predominantly inductive, causing a lagging secondary current. Because of the coupling between the windings, the net effect is to cause the phase relationships between the primary and secondary voltages to change. Since E_2 and E_3 are 180° out of phase, the vector sum of voltages E_1 and E_2 across V7A will increase and that of E_1 and E_3 across V7B will decrease. This is shown in C and D, figure 197.

6. When the input frequency is below resonance, the secondary of T2 appears predominantly capacitive, the higher voltage appears across V7B and the polarity of the output voltage is reversed. These conditions are represented by the vectors in E and F, figure 197.

7. Thus, the output voltage obtained is proportional to the frequency deviation of the carrier from its center frequency of 6 mc. Since the input voltage is varying above and below the carrier frequency at the modulation rate, the voltage at the discriminator output reproduces the original audio modulating signal.

8. The overall response curve of the discriminator is shown in figure 198. In this figure, the output is

zero when the carrier frequency is 6 mc; it rises linearly to +8.8 volts for a +80-kc deviation, and declines linearly to —8.8 volts for a —80-kc deviation. Since the input signal is frequency modulated by the audio signal, the output voltage has the same waveform as the original audio input. If the carrier frequency is exactly equal to 6 mc, this audio signal will vary about an axis of 0 volt. If the oscillator frequency drifts, however, the audio signal will vary about a dc voltage corresponding to the amount of drift. For example, if the carrier center frequency is 6.025 mc (+25 kc), the dc component is equal to about +3 volts. Similarly, if the carrier frequency is 5.975 mc (—25 kc), the dc component is equal to about —3 volts.

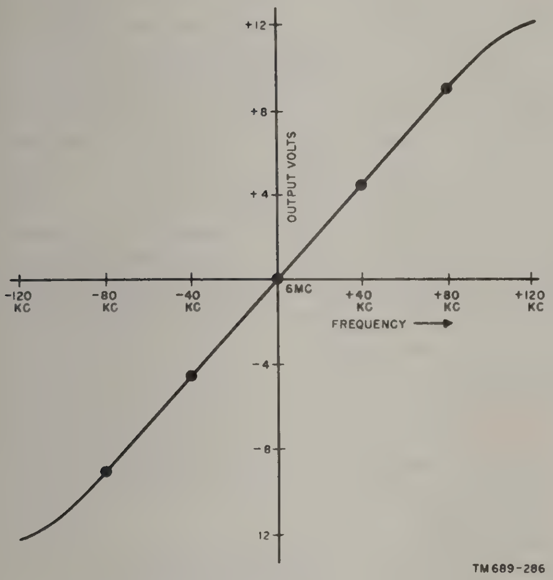


Figure 198. Discriminator response curve.

(*d*) *Afc amplifier V6A* (fig. 199).

1. The afc signal obtained at the output of the discriminator contains both dc and audio components. These components are separated by C24, R7, and C3. Resistors R36 and R37 form a voltage divider to audio frequencies and C24 effectively blocks the dc, so that only the audio signal will go to the monitor audio amplifier, V6B. Resistor R7 presents an ac so that the dc voltage is applied to the grid of V6A (one-half of a 2C51 twin triode). Any audio signal that reaches this point is bypassed to ground by capacitor C3 whose ac impedance is small compared to that of R7. Thus, the audio signal is applied to V6B and the dc signal to V6A.

2. The dc component of the discriminator output is applied to the grid of V6A, the afc amplifier, through section 2 of switch S1 when it is in

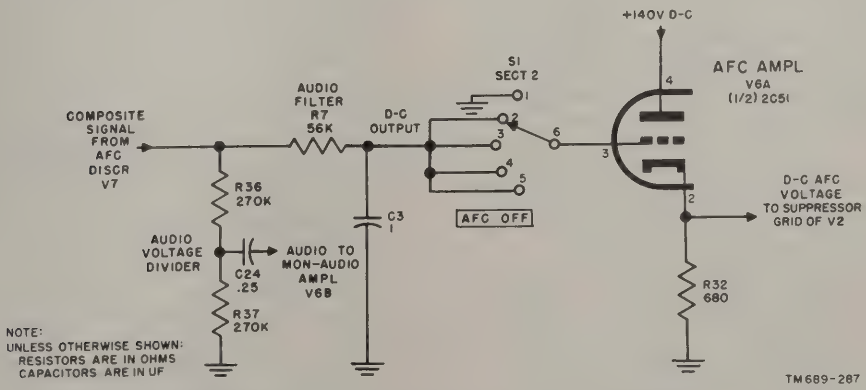

+140V D-C
AFC AMPL
V6A
(1/2) 2C51
S1
SECT 2
1
2
3
4
5
6
AFC OFF
AUDIO
FILTER
R7
56K
D-C
OUTPUT
COMPOSITE
SIGNAL
FROM
AFC
DISCR
V7
R36
270K
C3
1
AUDIO
VOLTAGE
DIVIDER
C24
.25
AUDIO TO
MON-AUDIO
AMPL
V6B
R37
270K
NOTE:
UNLESS OTHERWISE SHOWN:
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UF
4
3
2
D-C AFC
VOLTAGE
TO SUPPRESSOR
GRID OF V2
R32
680
TM689-287

Figure 199. Afc amplifier V6A, simplified schematic diagram.

position 2, 3, 4, or 5. If the dc component is positive, the tube draws more current and a larger voltage is developed across cathode resistor R32. The voltage across this resistor is applied to the suppressor grid of V2, the carrier oscillator. Increasing the voltage at the suppressor decreases the frequency of oscillation and tends to return the oscillator frequency to 6.0 mc. Similarly, a negative dc component decreases the voltage across R32 and, in turn, increases the oscillator frequency toward 6.0 mc. In this manner, the carrier-oscillator center frequency is stabilized at 6.0 mc.

(3) *Monitor audio amplifier V6B* (fig. 200). The audio output of the discriminator, V7, is fed through C24 to the grid of the monitor audio stage, V6B (one-half of a 2C51 twin triode). This stage is a cathode follower; it isolates the low-impedance meter circuit from the discriminator and indicates, by means of meter M1, the level of the audio input signal in terms of percent modulation. AUDIO METER SENS potentiometer R24, in the output circuit in series with R29, is adjusted so that a meter reading of 100 corresponds to ±50-kc deviation, or 100 percent modulation. The audio signal is obtained across cathode load resistors R34 and R33, which also act as a voltage divider to provide proper grid bias. Resistor R35 is the grid resistor. The output signal is coupled through C18.

(4) *Tone oscillator V5* (fig. 201).

(*a*) A 1,000-cps tone oscillator provides a test signal to aline the order-wire transmitter. The output of this oscillator can be fed to either the through or local channel. The output voltage of the oscillator is 0.776 volt (±3 db). In most installations, this is the same audio level (0.776 volt) that provides 100 percent modulation.

(*b*) The test tone oscillator, V5, uses a 5654/6AK5W pentode in a phase-shift oscillator circuit. This circuit operates in the following manner: assume that there is a 1,000-cps sine wave at the grid of V5, as in curve D, figure 201. This signal appears across plate resistor R26, 180° out of phase with the grid voltage, shown in curve A on figure 201. A

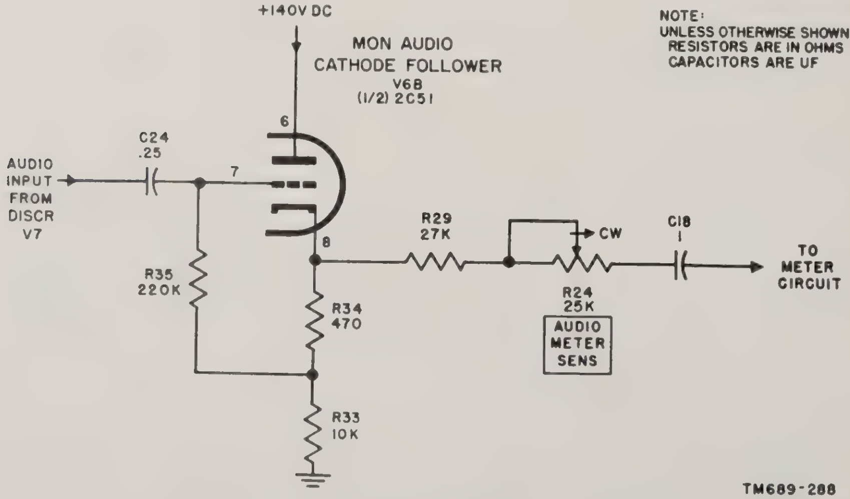
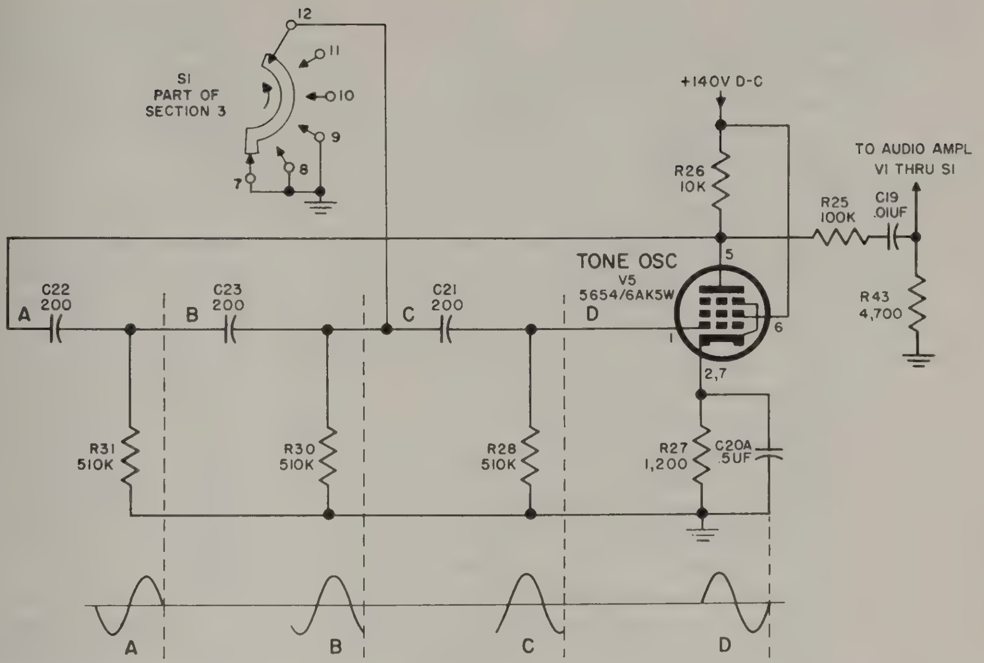

+140V DC
MON AUDIO
CATHODE FOLLOWER
V6B
(1/2) 2C51
NOTE:
UNLESS OTHERWISE SHOWN:
RESISTORS ARE IN OHMS
CAPACITORS ARE UF
6
C24
.25
AUDIO
INPUT
FROM
DISCR
V7
7
8
R29
27K
CW
C18
1
TO
METER
CIRCUIT
R35
220K
R34
470
R24
25K
AUDIO
METER
SENS
R33
10K
TM689-288

Figure 200. Monitor audio amplifier V6B, simplified schematic diagram.



NOTES:
1. UNLESS OTHERWISE SHOWN, RESISTORS ARE IN OHMS, CAPACITORS ARE IN UUF.
2. FOR UNITS BEARING ORDER NO. 1640–PHILA–51 SERIAL NOS. 1 THROUGH 297, THE PLATE AND SCREEN OF V5 ARE CONNECTED TO B+ THROUGH S1.

TM689–289

Figure 201. Tone oscillator V5, simplified schematic diagram.

portion of this voltage is coupled back to the grid through three L-section phase-shifting networks, C22–R31, C23–R30, and C21–R28. Each network shifts the phase about 60° at 1,000 cps, as illustrated by curves B, C, and D. The total phase shift from the plate to the grid at 1,000 cycles is 180°. Adding to this 180° phase shift from grid to plate in the tube results in a total phase shift of the signal from grid back to grid of 360°. The signal fed back to the grid is in phase with the original signal and the stage will oscillate at 1,000 cps.

(*c*) Each RC network provides a phase shift of about 60° only at 1,000 cps. At other frequencies the phase shift is not 60°, the total phase shift is not 360°, and the feedback is not in phase and regenerative. Therefore, the circuit oscillates only at or near 1,000 cps. Cathode bias is provided by R27, and C20A is the cathode by-pass capacitor. The output of the oscillator is coupled to the through and local channels through coupling network R25 and C19 and through positions 4 and 5 of switch S1. Note that plate and screen voltages are furnished to the tube through section 3 of S1 only when the switch is in position 4 or 5.

Note. For Order-Wire Transmitter T–389/TRC–29 on Order No. 15739–Phila–55 (serial No. 298–417), the screen and plate voltages of V5 are not applied through section 3 of S1. The screen and plate are connected directly to the B+ line so that B+ is always present at these points. The tone oscillator is disabled by grounding the phase-shift network through switch S1 when this switch is in other than position 4 or 5.

(5) *Power supply, V9 through V12* (fig. 202).

(*a*) *General.* The power supply delivers 60 ma of regulated dc at + 140 volts. The supply consists of a full-wave rectifier, RC filter, and a voltage regulator circuit.

(*b*) *Full-wave rectifier V9.*

1. Primary power for the full-wave rectifier is obtained from terminals 8 and 10 of TB1, through PLATE current circuit breaker CB1, and transformer T4. The circuit breaker is a magnetic delay type and serves both as an ON–OFF switch for the plate and screen voltages and to protect against overloads. Similarly, FIL circuit breaker CB2 in the T5 filament transformer primary line provides both a filament ON–OFF switch and overload protection.

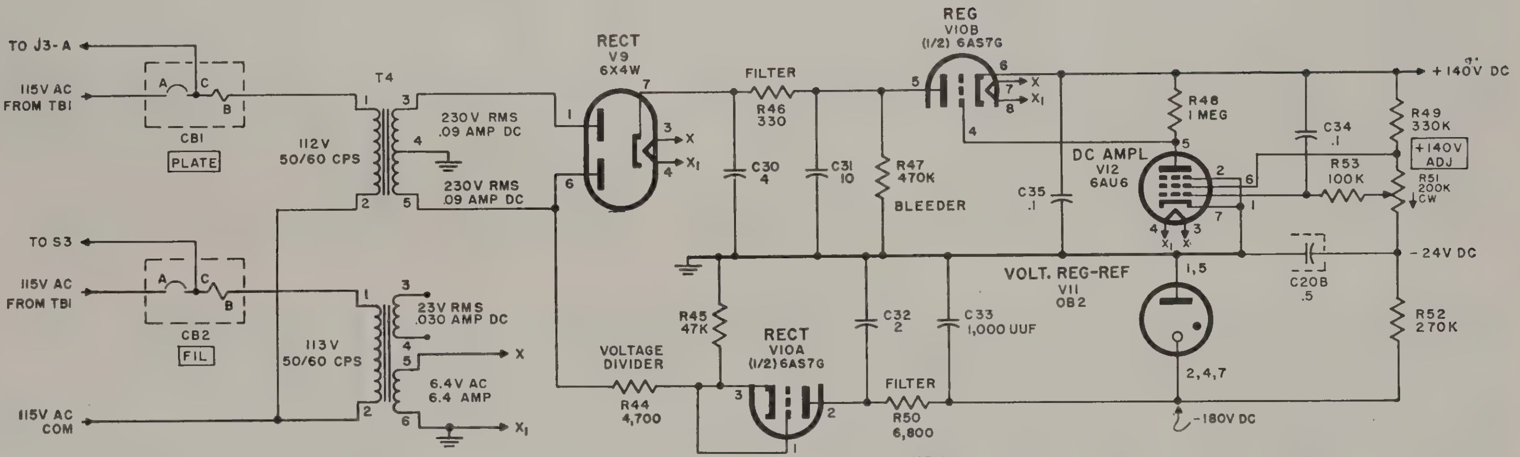
2. The secondary output voltage of transformer T4 is applied to the plates of V9, a 6X4W twin diode, connected as a full-wave rectifier. The output of this rectifier circuit is filtered by RC filter C30–R46–C31. The voltage at the output of the filter is about 225 volts. This voltage then is fed to the voltage regulator circuit, which regulates it to +140 volts.

(*c*) *Voltage regulator circuit, V10 to V12.*

1. The voltage regulator circuit includes three tubes that perform four functions. Tube V10B, one-half of a type 6AS7G twin triode, is used as a series regulator. The dc control amplifier, V12, is a 6AU6 pentode. An OB2 is used as the voltage reference tube, V11, and V10A, the other half of the 6AS7G twin diode, is used as a rectifier to furnish operating potential for V11.

2. The circuit is arranged conventionally according to common series voltage regulator practice, although it contains one unusual feature. The voltage reference tube, V11, instead of being used to decrease the variable control voltage between the output level and ground, here is used to increase that range, to make the circuit more easily controllable. The voltage reference tube is connected between the bottom of the control tube voltage divider and ground with its cathode connected to the voltage divider and the plate grounded. An ac voltage is taken across one-half of the plate supply transformer winding and rectified by V10A, which is diode-connected. The output of this tube is about —200 volts dc. It is passed through an RC filter, in which C32 and C33 are the filter capacitors and R50 the series resistor. Resistor R50 also serves as a voltage dropping and current-limiting resistor for V11. The filter output is connected to the cathode of V11, establishing a fixed level of —108 volts dc at that point, extending the voltage across the R49–R51–R52 voltage divider from +140 volts to —108 volts, or a total range of 248 volts. This allows the voltage at the grid of control amplifier V12 to be set at any point from approximately +38 volts to approximately —24 volts with respect to its cathode, which is grounded. In this manner, an extremely wide range of control is obtained for the dc amplifier tube, V12. This arrangement is necessary because the allowable voltage drop across series regulator tube V10B is relatively small (85 volts).

Note. For Order-Wire Transmitter T–389/TRC on Order No. 1640–Phila–51 (serial No. 115–297) and Order No. 15739–Phila–55 (serial No. 298–417), the voltage regulating circuit in the order-wire transmitter power supply has been improved by increasing the gain of the dc amplifier. This has been done by decreasing the screen voltage of tube V12.


TO J3-A
115V AC FROM TB1
TO S3
115V AC FROM TB1
115V AC COM
A
C
B
CB1
PLATE
CB2
FIL
T4
112V 50/60 CPS
113V 50/60 CPS
230V RMS .09 AMP DC
230V RMS .09 AMP DC
23V RMS .030 AMP DC
6.4V AC 6.4 AMP
X
X1
RECT V9 6X4W
FILTER R46 330
C30 4
C31 10
R47 470K BLEEDER
REG V10B (1/2) 6AS7G
C35 .1
DC AMPL V12 6AU6
R48 1 MEG
C34 .1
R49 330K
+140V ADJ
R51 200K CW
R53 100K
+140V DC
-24V DC
C20B .5
R52 270K
VOLT. REG-REF V11 OB2
1,5
2,4,7
-180V DC
VOLTAGE DIVIDER R44 4,700
R45 47K
RECT V10A (1/2)6AS7G
C32 2
C33 1,000 UUF
FILTER R50 6,800

NOTE:
FOR ORDER WIRE TRANSMITTER T-389/TRC-29 BEARING ORDER NO. 1640-PHILA.-51 SERIAL NOS. 1 THROUGH 115, PIN 6 OF V12 IS CONNECTED TO THE +140 V DC OUTPUT.

TM 689-290

Figure 202. Power supply circuit V9 through V12, simplified schematic diagram.

3. Resistors R44 and R45 are used as a voltage divider to reduce the voltage at the input of rectifier V10A. Capacitor C20B helps to stabilize the voltage across R52 (and the voltage reference tube). Resistor R48 is the plate load for V12 and R53 serves to isolate the V12 grid. Capacitor C34 improves the regulation of the supply against ripple and transient voltage waveforms, and C35, across the output of the supply, reduces further the ripple content of the dc output voltage, as well as improving the decoupling of the supply from signal voltages in the various stages of the order-wire transmitter.
4. Assume that the output voltage of voltage regulator increases. This increase in voltage causes a rise in the grid voltage of control amplifier V12, which increases the current flow through the tube. The increased current flow causes a larger voltage drop across plate-load resistor R48, resulting in a decreased voltage at the plate of V12. Since the plate of V12 is connected directly to the grid of series regulator tube V10B, the grid voltage of V10B is reduced correspondingly. This increases the series resistance of V10B, and its output voltage is reduced, returning to its original assigned value of +140 volts, which has been set by potentiometer R51.
5. Conversely, if the output voltage decreases, the voltage at the grid of V12 decreases, its plate voltage increases; the grid voltage of V10B increases, and the output voltage increases. If the input voltage from the rectifier fluctuates, similar actions take place and the output voltage is maintained at its normal value.

(6) *Order-wire test switch circuit* (fig. 190).

(*a*) The order-wire test switch, S1, is a 3-section, 6-circuit, 5-position-per-circuit rotary type. It is used with various tests and adjustments on the equipment. The six circuits controlled simultaneously are as follows: local channel audio input, through channel audio input, discriminator output to meter, afc signal to afc amplifier (afc on–off), plate voltage to tone oscillator, and audio signal selection to meter.

(*b*) In the first position, AFC OFF, the connection between the dc output of the afc discriminator, V7, and the the grid of the afc amplifier, V6A, is broken (section 2, pin 1) and the afc amplifier input is grounded. In this position, the carrier oscillator is free-running and the afc system is disabled. In all other positions of the switch, the afc signal is connected to the carrier oscillator.

(*c*) In the second position, OPR, the unit operates normally. The afc signal is connected to the carrier oscillator, the signal from the through channel is connected to its audio amplifier (section 2, right hand side), the local audio signal is connected to its audio amplifier (section 1, right hand side), and the meter reading indicates percent modulation when meter selector switch S2 is set at AUDIO. The operation of this latter switch is described in (7) below. The meter is connected to the monitor audio amplifier stage, V6B, through section 3, left hand side, of switch S1. The tone oscillator is inoperative.

(*d*) In the third position, INPUT AUDIO, the same connections as for position 2 are made, except that the meter is connected to the output of audio transformer T1 by contact 3 of the left hand side of section 3 of switch S1. In this case the meter reading, with the meter selector switch in AUDIO position, indicates the level of the audio modulating signal instead of the percent modulation.

(*e*) In the fourth position, THRU TONE, plate voltage is supplied to the test tone oscillator, V5, through the right hand side of section 3 of S1, and its output is connected to the through channel through the right hand side of section 2 of S1. The normal through channel and local channel audio signals are disconnected, and the grid of the local channel audio amplifier is grounded.

(*f*) In the fifth position, LOCAL TONE, the output of the test tone oscillator, V5, is connected to the local channel through the left hand side of section 1 of S1, the normal through and local channel audio signals are disconnected, and the grid of the through channel audio amplifier is grounded.

(7) *Metering circuit* (fig. 203).

(*a*) Meter selector switch S2 is a 5-position, 2-circuit switch that selects the signal metered by meter M1. In the first position, CARR LIM GRID, the meter measures the voltage across grid resistor R14 of carrier limiter V3. This meter reading indicates the relative level of the 6-mc carrier oscillator signal.

(*b*) In the second position, DISCR+, the dc output of the discriminator is fed to the meter through one of two meter multiplier circuits. When ORDER WIRE TEST SWITCH S1 is at AFC OFF (position 1), the meter multiplier circuit consists of R6 and R3 in series (fig. 190). In any other position of the ORDER WIRE TEST SWITCH, however, the circuit consists only of R6, increasing the sensitivity of the meter circuit. The reason for this is that reduced sensitivity is required with the AFC OFF to permit a less sensitive alinement procedure.

(*c*) In the third position, DISCR—, the output of the discriminator is connected in the same manner as in position 2, except that the meter leads are reversed so that negative dc voltages can be indicated.

(*d*) The fourth switch position, AUDIO, measures either the output of monitor audio amplifier V6B (when S1 is in position 1, 2, 4, or 5) or the voltage across the secondary of T1 (when S1 is in position 3). The audio signal is rectified by crystal rectifiers CR1 and CR2.

(*e*) The fifth position, +140V, measures the +140-volt bus through voltage-dividing network R22 and R23.

(8) *Transfer control connections* (fig. 204).

(*a*) Completion of connections between the transmitting equipment and suitable transfer control equipment is made through the transmitter order-wire chassis. These connections are completely independent of the other circuits in this chassis. When transfer control facilities are available they are connected to J3. Connections exist between pins of this jack and various terminals on terminal board TB1. By means of these connections, monitoring signals are made available to transfer control equipment so that it can detect a failure in an operating transmitter and effect changeover to standby equipment. This occurs when the carrier signal fails, when it deviates from its assigned frequency by more than a predetermined amount, or when there is any other fault detected and indicated by the order-wire monitor circuit in the transmitter.

(*b*) The characteristics of the operating transmitter monitored are: presence or absence of the order-wire carrier; frequency of the main transmitter carrier, obtained as a dc signal from the discriminator of the afc, if. amplifier in Radio Transmitter T–303/G. For further information on the sources and characteristics of these signals, refer to paragraphs 166*c*(2)(*g*), 167*c*(4), and 168.

(*c*) The circuit is arranged as follows:

1. Order-wire carrier failure closes

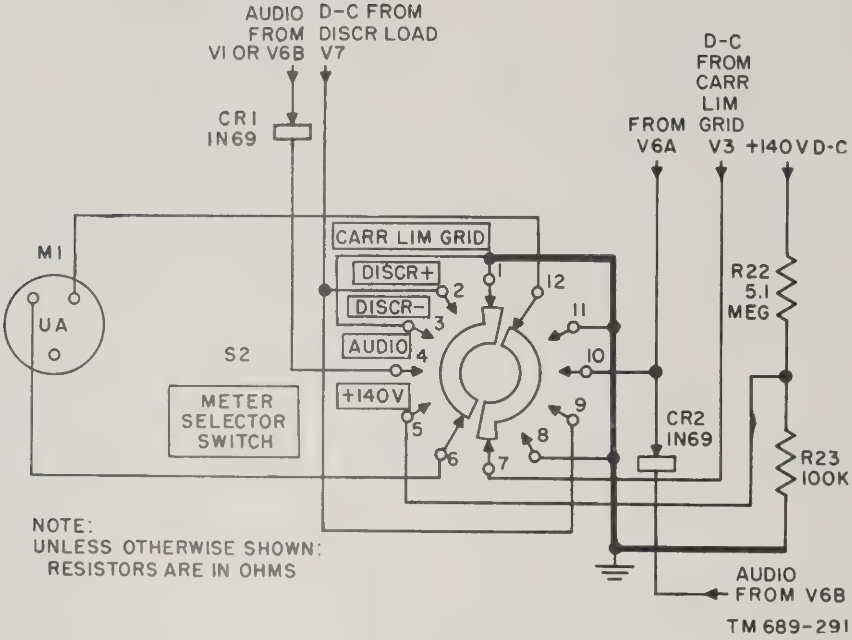

AUDIO FROM V1 OR V6B
D-C FROM DISCR LOAD V7
D-C FROM CARR LIM GRID V3
FROM V6A
+140V D-C
CR1 IN69
M1
UA
S2
METER SELECTOR SWITCH
CARR LIM GRID
DISCR+
DISCR-
AUDIO
+140V
1
2
3
4
5
6
7
8
9
10
11
12
R22 5.1 MEG
R23 100K
CR2 IN69
NOTE:
UNLESS OTHERWISE SHOWN:
RESISTORS ARE IN OHMS
AUDIO FROM V6B
TM 689-291

Figure 203. Metering circuit, simplified schematic diagram.

contacts on K4 in vtvm chassis in Radio Transmitter T–303/G which are connected to terminals 1 and 2 of TB 1 and then to pins H and J of J3. Pins H and J are shorted by order-wire failure.

2. The afc monitor line (obtained from the transmitter monitor receiver discriminator) is fed to terminal 3 of TB1 and then to pin F of jack J3.

3. Ground connection is made between terminal 4 of TB1 and pin G of J3.

4. 115-volt power for the TRANSFER CONTROL ON lamp is provided from terminal 5 of TB1 which is connected to the midpoint of the front meter panel breaker. Power is applied to this lamp (I 1) only when switch S4 is in the TRANSFER CONTROL position.

5. Power to complete the interlock circuit is applied to terminal 6 of TB1 through S4 when the latter is in the MANUAL OPERATE position. When S4 is in the TRANSFER CONTROL position, the interlock circuit is opened, and changeover is accomplished by closing the interlock circuit across pins C and D of J3 by means of the transfer control equipment. This completes the circuit from the FIL contactor, CB2, through the order-wire transmitter interlock switch S3, through J3, into the transfer control equipment, and back again to terminal 6 of TB1, which continues to the rest of the interlock switches.

6. When all breakers are closed, power is supplied to terminal A of J3 as a primary power ready signal for the transfer equipment.

7. The ac power common return line is connected to terminal B of J3.

172. Power Supply PP–764/G

a. General. Power Supply PP–764/G is the transmitter high-voltage power supply. It con-

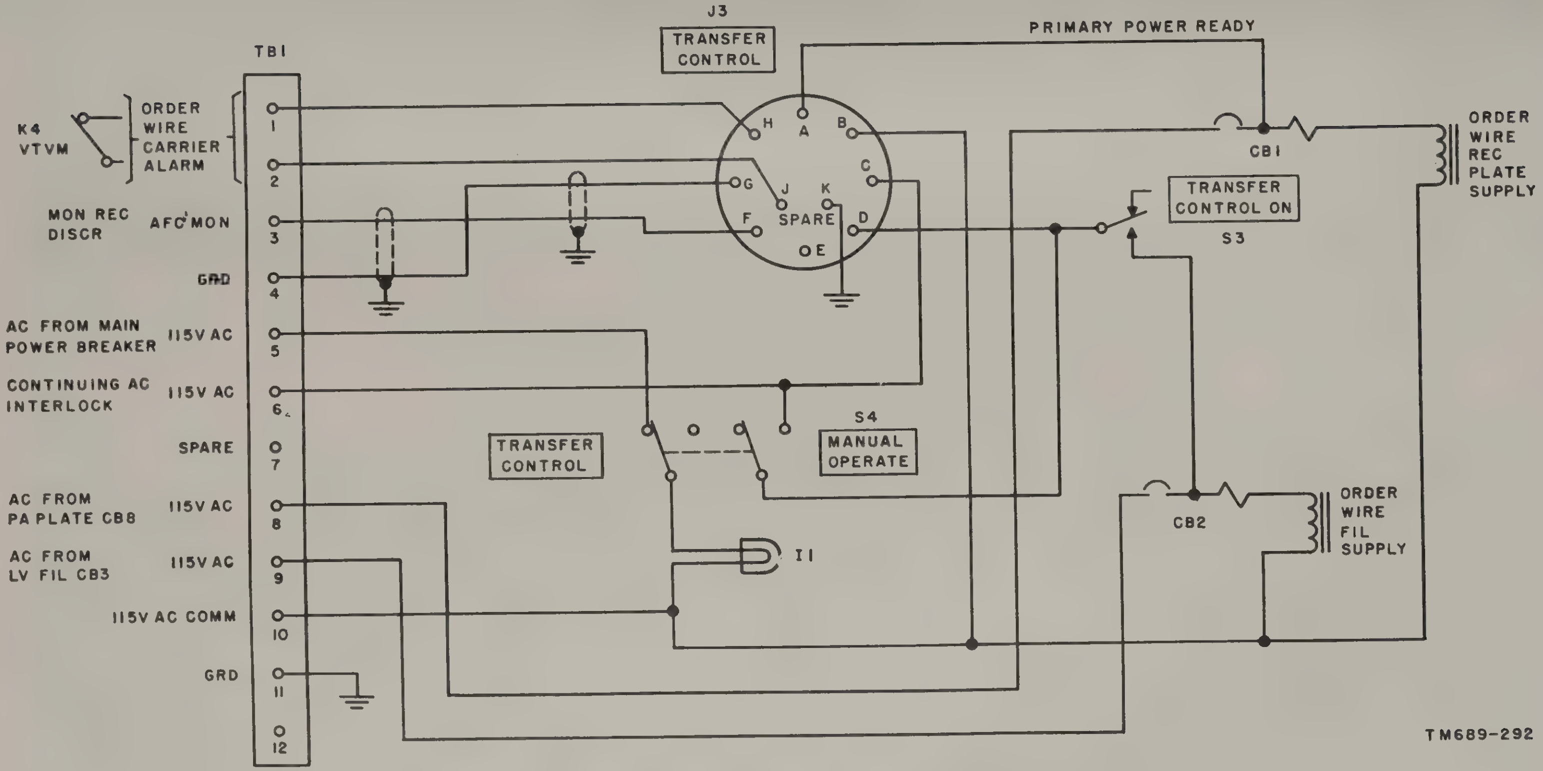

J3
TRANSFER CONTROL
PRIMARY POWER READY
TB1
K4 VTVM
ORDER WIRE CARRIER ALARM
MON REC DISCR
AFC MON
GRD
AC FROM MAIN POWER BREAKER
115V AC
CONTINUING AC INTERLOCK
115V AC
SPARE
AC FROM PA PLATE CB8
115V AC
AC FROM LV FIL CB3
115V AC
115V AC COMM
GRD
1
2
3
4
5
6
7
8
9
10
11
12
H
A
B
C
G
J
K
F
SPARE
D
OE
CB1
ORDER WIRE REC PLATE SUPPLY
TRANSFER CONTROL ON
S3
S4
MANUAL OPERATE
TRANSFER CONTROL
CB2
ORDER WIRE FIL SUPPLY
I1
TM689-292

Figure 204. Transfer control circuits, simplified schematic diagram.

tains three independent rectifier circuits that deliver one regulated and two unregulated dc voltages to Radio Transmitter T–303/G. A multiwinding filament transformer also furnishes filament voltages for the tubes in the radio transmitter. Several low-voltage dc potentials obtained from Power Supply PP–689/G (par. 173) are connected through this power supply for use in the radio transmitter. In addition, control and indicating facilities for the 115-volt ac power are provided.

b. Block Diagram Description (fig. 205).

(1) The power supply contains three rectifier circuits that supply to the radio transmitter —1,000 volts dc regulated beam voltage, —1,350 volts dc unregulated reflector voltage, both for the klystron oscillator, and 0 to +900 volts dc unregulated power amplifier plate voltage. Power transformer T2 converts the 115-volt, ac line voltage to the voltages required for the beam voltage and reflector voltage rectifiers. Power transformer T4 converts the 115-volt, ac line voltage to the voltage required by the power amplifier, plate voltage rectifier. Full-wave rectifier tubes V1 and V2 and a filter circuit are used to furnish the voltage to the —1,000-volt, dc regulator. Series regulator tubes V3 through V6 and dc control amplifier tube V7 are used to maintain the output of this regulator constant. A fixed reference voltage is applied to V7 by the voltage reference tube V8. Changes in output voltage are transmitted to the control amplifier grid across a portion of the resistive network in the output. Tubes V9 and V10, connected in a voltage-doubler circuit, together with a filter network, supply the floating —1,350 volts dc. Tube V11, connected as a full-wave rectifier, plus another filter network, supply the 0 to +900 volts dc.

(2) Regulated dc voltages of 300 volts, 250 volts, 150 volts, 42 volts, and —150 volts enter the supply at J8, to which they are sent by transmitter low-voltage power supply. These are not used within the high-voltage supply, but are passed on to be connected to the radio transmitter. Primary line power also is supplied to the low-voltage supply through this connector.

(3) Filament transformer T5 contains five windings that furnish filament voltages for tubes in various parts of the radio transmitter in addition to supplying filament voltage to the power amplifier plate rectifier, V1.

(4) Time-delay and power relays, switches, circuit breakers, power outlets, fuses, and indicating lamps also are contained in the power supply. All of these are used in conjunction with the 115-volt powerlines.

c. Detailed Circuit Description.

(1) *—1,000-volt beam supply* (fig. 206).

(*a*) In the —1,000-volt beam supply, half-wave diodes V1 and V2 (type 836) are connected in a full-wave rectifier circuit. The negative output of the rectifier circuit is taken from the center tap (terminal 6) on a secondary winding of power transformer T2. The positive side of the rectifier circuit is ungrounded to provide approximately +300 volts to operate the regulator tubes. The output is filtered by a pi-type filter that consists of capacitors C1 and C2 and inductor L1. The output appears across the resistive network that consists of R25 through R34. Four type 807 regulator tubes, V3 through V6, are in series with the rectifier output; for simplicity, these tubes are represented by a single tube designated V3 on figure 206. The four tubes act in parallel, the circuits for all of them being identical. The bias on V3 is varied by control tube V7, a 6AU6 dc amplifier. The cathode voltage on V7, in turn, is controlled by voltage reference tube V8, a type 0A2, providing a fixed bias. The grid voltage for V7 is obtained from the arm of BEAM V ADJ potentiometer R36, part of a voltage divider which reflects any change in output voltage. A change in potential at the output results in a proportional change in the grid

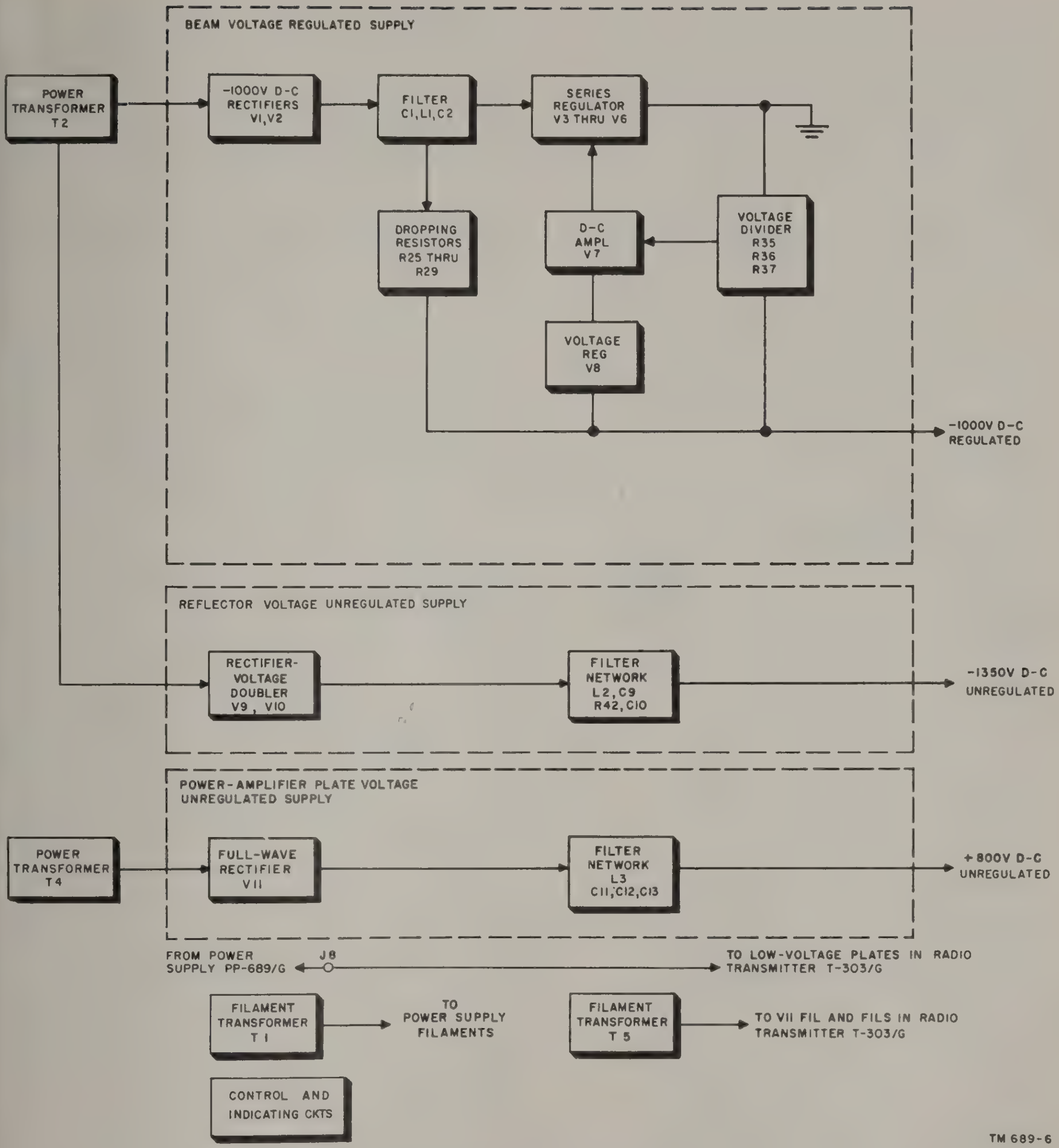

BEAM VOLTAGE REGULATED SUPPLY
POWER TRANSFORMER T2
-1000V D-C RECTIFIERS V1,V2
FILTER C1,L1,C2
SERIES REGULATOR V3 THRU V6
DROPPING RESISTORS R25 THRU R29
D-C AMPL V7
VOLTAGE DIVIDER R35 R36 R37
VOLTAGE REG V8
-1000V D-C REGULATED
REFLECTOR VOLTAGE UNREGULATED SUPPLY
RECTIFIER-VOLTAGE DOUBLER V9 , V10
FILTER NETWORK L2,C9 R42,C10
-1350V D-C UNREGULATED
POWER-AMPLIFIER PLATE VOLTAGE UNREGULATED SUPPLY
POWER TRANSFORMER T4
FULL-WAVE RECTIFIER V11
FILTER NETWORK L3 C11,C12,C13
+800V D-C UNREGULATED
FROM POWER SUPPLY PP-689/G
J8
TO LOW-VOLTAGE PLATES IN RADIO TRANSMITTER T-303/G
FILAMENT TRANSFORMER T1
TO POWER SUPPLY FILAMENTS
FILAMENT TRANSFORMER T5
TO V11 FIL AND FILS IN RADIO TRANSMITTER T-303/G
CONTROL AND INDICATING CKTS
TM 689-6

Figure 205. Power Supply PP–764/G, block diagram.

voltage of V7. The resultant change in current through plate-load resistor R1 changes the plate voltage of tube V7 and, consequently, the grid voltage of series regulator tube V3. The change in grid voltage of V3 changes the impedance of this tube so that the voltage drop across it varies in such a manner as to maintain the output voltage constant.

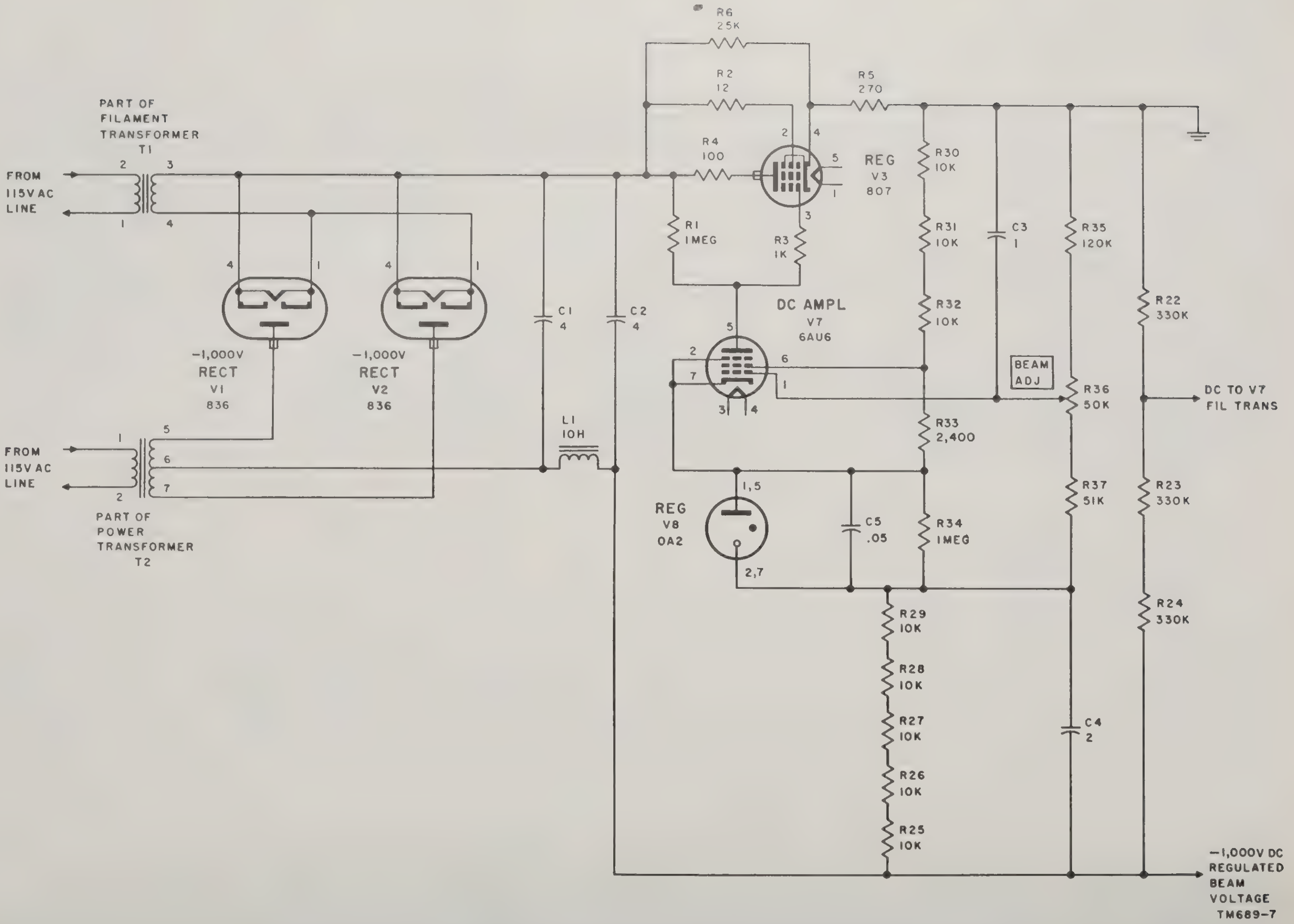

R6
25K
R2
12
R5
270
PART OF
FILAMENT
TRANSFORMER
T1
FROM
115V AC
LINE
R4
100
REG
V3
807
R30
10K
R31
10K
R32
10K
R33
2,400
R34
1MEG
R1
1MEG
R3
1K
C3
1
R35
120K
R22
330K
C1
4
C2
4
DC AMPL
V7
6AU6
BEAM
ADJ
R36
50K
DC TO V7
FIL TRANS
-1,000V
RECT
V1
836
-1,000V
RECT
V2
836
L1
10H
FROM
115V AC
LINE
PART OF
POWER
TRANSFORMER
T2
REG
V8
OA2
C5
.05
R37
51K
R23
330K
R24
330K
R29
10K
R28
10K
R27
10K
R26
10K
R25
10K
C4
2
-1,000V DC
REGULATED
BEAM
VOLTAGE
TM689-7

Figure 206. —1,000-volt beam supply, V1 through V8, simplified schematic diagram.

(*b*) Capacitors C4 and C5 minimize the effect of transient voltage variations on the cathode voltage of V7, while C3 increases the sensitivity of the grid to such changes by passing the entire effect of sharp changes to the grid, rather than the smaller portion of such changes which would be obtained from R36, with relatively poor response time. Resistors R2, R3, R4, and R5 serve for isolation, parasitic suppression, and current equalization in the V3 circuits. Similar components used for these purposes with V4, V5, and V6 may be found on the complete schematic diagram. A dc voltage taken from the junction of R22 and R23 is connected to the center tap of the filament winding supplying V7, maintaining the tube filament at a fixed negative potential, comparable to that at the cathode, to keep the filament-cathode voltage drop low and thus prevent breakdown.

(*c*) The effect of the action described in (*a*) above can be understood by analyzing a change in line voltage that appears across the primary of power transformer T2. Assume that an increase in line voltage increases the output voltage of the rectifier, which results in the lower end of the resistive network across the output becoming more negative. Part of this change appears across the voltage-divider network that consists of resistors R35 and R37 and potentiometer R36. Because of the action of the voltage reference tube, V8, the only portion of the change reflected between grid and cathode of V7 is that tapped off the voltage divider. The result of this arrangement is to make the grid more positive with respect to the cathode. The consequent increase in current flow through V7 decreases the plate voltage of the tube. This decrease in voltage is fed to the grid of V3 through resistor R3, resulting in an increase in the resistance of V3 and increased voltage drop across it. The circuit parameters are so chosen that this increase in voltage drop across V3 compensates for the rise in output voltage. Should the input voltage decrease, reverse action takes place. The same holds true for changes in output voltages. The net effect is to hold the output voltage constant at a level determined by the setting of R36, the BEAM V ADJ potentiometer.

(2) *—1,350-volt reflector supply* (fig. 207). Full-wave rectifiers V9 and V10, type 5R4WGY, are connected in a voltage-doubler arrangement to provide the —1,350-volt reflector supply voltage. The voltage that appears across terminals 3 and 4 of a secondary winding on power transformer T2 is applied across the voltage-doubler circuit. Capacitor C6 acts as a high-frequency bypass. When terminal 3 of the secondary is positive with respect to terminal 4, V9 conducts, charging capacitor C7 with the polarity shown. The cathode of V10 is positive with respect to its plate during this half-cycle and, therefore, does not conduct. When terminal 4 is positive with respect to terminal 3, V89 stops conducting and V10 conducts, charging capacitor C8 with the polarity shown. Since capacitors C7 and C8 are in series and charge with the same polarity, the voltages across them add, and the output voltage is approximately double that of the peak voltage between terminals 3 and 4 on the transformer secondary. The doubler output is fed to the choke-input filter which consists of inductor L2 and capacitor C9, then to an RC type filter consisting of resistor R42 and capacitor C10. Capacitor C10 is returned to the negative output terminal of the —1,000-volt beam supply to obtain the desired bypassing. The output is taken from two ungrounded terminals, allowing the supply to *float*. The voltage at the upper terminal is approximately —650 volts, that at the lower is approximately —2,000 volts,

the total supply potential being about −1,350 volts. This output is fed to the electronic voltage regulator subchassis in the radio transmitter (par. 170), where it is regulated before being applied to the klystron.

(3) *Zero to +900-volt power amplifier plate supply* (fig. 208). Full-wave rectifier V11, a type 5R4WGY, is connected in a conventional full-wave rectifier circuit across terminals 3, 4, and 5 of the secondary winding on power transformer T4. The output is filtered by the choke-input filter consisting of inductor L3 and capacitors C11 and C12. The output of the filter is ungrounded. It is taken across the B+ and B− terminals and fed to the radio transmitter chassis. Capacitor C13 provides a bypass for the B− leg. The primary voltage of T4 can be varied from 0 to 115 volts ac by VARIABLE AUTOTRANSFORMER T3 on the power supply chassis, which effectively controls the voltage fed to the power amplifier over the range of 0 to +900 volts dc.

173. Power Supply PP–689/G

a. General. Power Supply PP–689/G is the low-voltage power supply for Radio Transmitter T–303/G. It contains three rectifier circuits that furnish five regulated voltages to the transmitter. These voltages are +300, +250, +150, +42, and −150 volts dc. The output voltages are sent through high-voltage power supply from which point they, together with the high voltages furnished by that supply, are fed to the radio transmitter. The unit is equipped with two pilot lights that indicate when the tube fila-

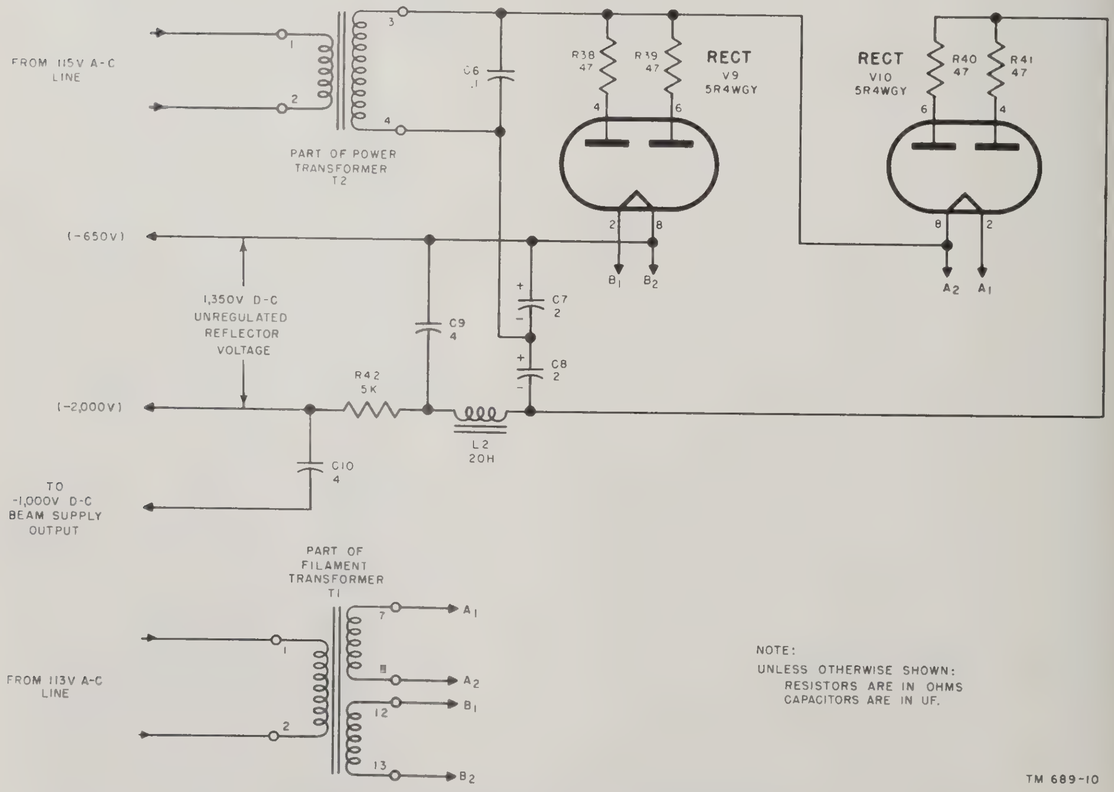

FROM 115V A-C LINE
1
2
3
4
C6 .1
PART OF POWER TRANSFORMER T2
R38 47
R39 47
RECT V9 5R4WGY
RECT V10 5R4WGY
R40 47
R41 47
(-650V)
1,350V D-C UNREGULATED REFLECTOR VOLTAGE
B1
B2
A2
A1
C7 2
C9 4
C8 2
R42 5K
(-2,000V)
L2 20H
C10 4
TO -1,000V D-C BEAM SUPPLY OUTPUT
PART OF FILAMENT TRANSFORMER T1
FROM 113V A-C LINE
7
8
12
13
NOTE:
UNLESS OTHERWISE SHOWN:
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UF.
TM 689-10

Figure 207. —1,350-volt reflector supply V9 and V10, simplified schematic diagram.

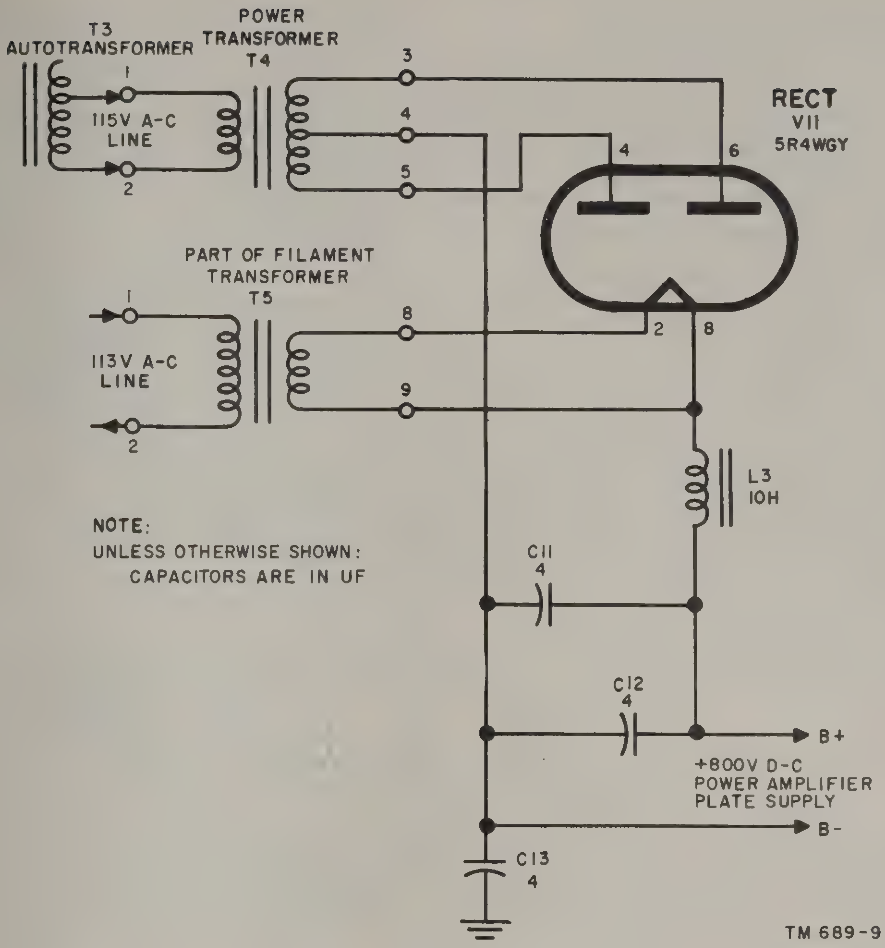

T3
AUTOTRANSFORMER
POWER
TRANSFORMER
T4
1
115V A-C
LINE
2
3
4
5
RECT
V11
5R4WGY
4
6
PART OF FILAMENT
TRANSFORMER
T5
1
113V A-C
LINE
2
8
9
2
8
L3
10H
NOTE:
UNLESS OTHERWISE SHOWN:
CAPACITORS ARE IN UF
C11
4
C12
4
B+
+800V D-C
POWER AMPLIFIER
PLATE SUPPLY
B-
C13
4
TM 689-9

Figure 208. Zero to +900-volt plate supply V11, simplified schematic diagram.

ments are on and when the low-voltage dc regulators are operating.

b. Block Diagram Description (fig. 209).

(1) Power transformer T2 is used to convert the 115-volt, ac line voltage to the voltages required for the +300- and +250-volt rectifiers. Power transformer T3 converts the line voltage to the voltage required for the —150-volt rectifier.

(2) Full-wave rectifier tube V1 and a filter network furnish the input voltage to the +300-volt dc regulator. Series regulator tube V2 and dc control amplifier V3 maintain the output voltage constant. Reference bias for V3 is provided by the —150-volt regulated supply. Changes in input or output voltage are transmitted to the dc control amplifier grid through a portion of a voltage divider across the output. The dc control amplifier adjusts the resistance of the series regulator, which compensates for the change.

(3) Full-wave rectifier tubes V4, V5, and V6 and a filter circuit furnish dc voltages for both the +250- and +150-volt supplies. Voltage regulators and control amplifiers that operate in the same manner as the one described for the +300-volt regulated supply maintain both outputs constant. In the +250-

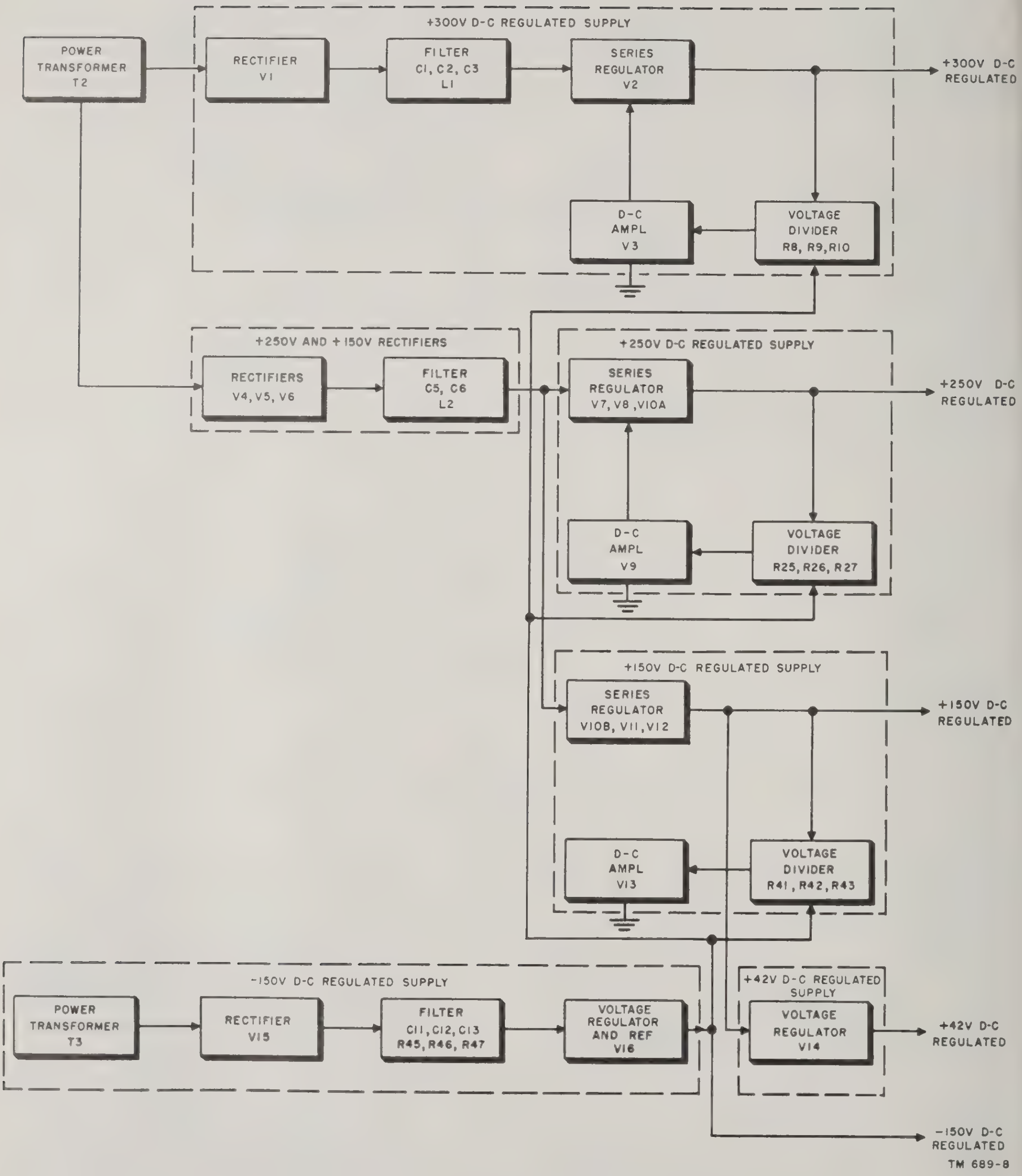

+300V D-C REGULATED SUPPLY
POWER TRANSFORMER T2
RECTIFIER V1
FILTER C1, C2, C3 L1
SERIES REGULATOR V2
+300V D-C REGULATED
D-C AMPL V3
VOLTAGE DIVIDER R8, R9, R10
+250V AND +150V RECTIFIERS
RECTIFIERS V4, V5, V6
FILTER C5, C6 L2
+250V D-C REGULATED SUPPLY
SERIES REGULATOR V7, V8, V10A
+250V D-C REGULATED
D-C AMPL V9
VOLTAGE DIVIDER R25, R26, R27
+150V D-C REGULATED SUPPLY
SERIES REGULATOR V10B, V11, V12
+150V D-C REGULATED
D-C AMPL V13
VOLTAGE DIVIDER R41, R42, R43
-150V D-C REGULATED SUPPLY
POWER TRANSFORMER T3
RECTIFIER V15
FILTER C11, C12, C13 R45, R46, R47
VOLTAGE REGULATOR AND REF V16
+42V D-C REGULATED SUPPLY
VOLTAGE REGULATOR V14
+42V D-C REGULATED
-150V D-C REGULATED
TM 689-8

Figure 209. Power Supply PP–689/G, block diagram.

volt supply, V7, V8, and V10A are the regulators, and V9 is the control amplifier. Tubes V11, V12, and V10B are the regulators, and V13 is the control amplifier for the +150-volt circuit.

(4) Part of the output of the +150-volt supply is fed to a voltage regulator tube, V14, which provides a regulated output of approximately +42 volts.

(5) Full-wave rectifier tube V15 furnishes the input voltage for —150-volt dc supply. Voltage regulator tube V16 is used to obtain the —150-volt dc output voltage. Besides being used for bias voltage in various parts of the radio transmitter, the —150-volt output is used as a reference level for the other regulator circuits in this power supply.

c. Detailed Circuit Description.

(1) *+300-volt regulated supply* (fig. 210).

(*a*) Tube V1, a 5R4WGY, is connected as a full-wave rectifier across a secondary winding of power transformer T2 to provide the necessary high voltage. The rectified output is taken at the filament of V1 and fed to a pi-type filter consisting of inductor L1 and capacitors C1, C2, and C3. Inductor L1 and capacitor C2 form a parallel-resonant trap circuit to reduce the undesired ripple frequency. The filter output is applied to the plates of series regulator tube V2, a 6AS7G twin triode, both sections of which are connected in parallel. The output is taken from the cathodes of this tube through current-equalizing resistors R3 and R4. A voltage divider that consists of resistors R8 and R10 and potentiometer R9 is placed between the +300-volt regulated output and the —150-volt regulated output ((5) below). This, together with the grounded cathode of V3, stabilizes the dc bias conditions on the tube.

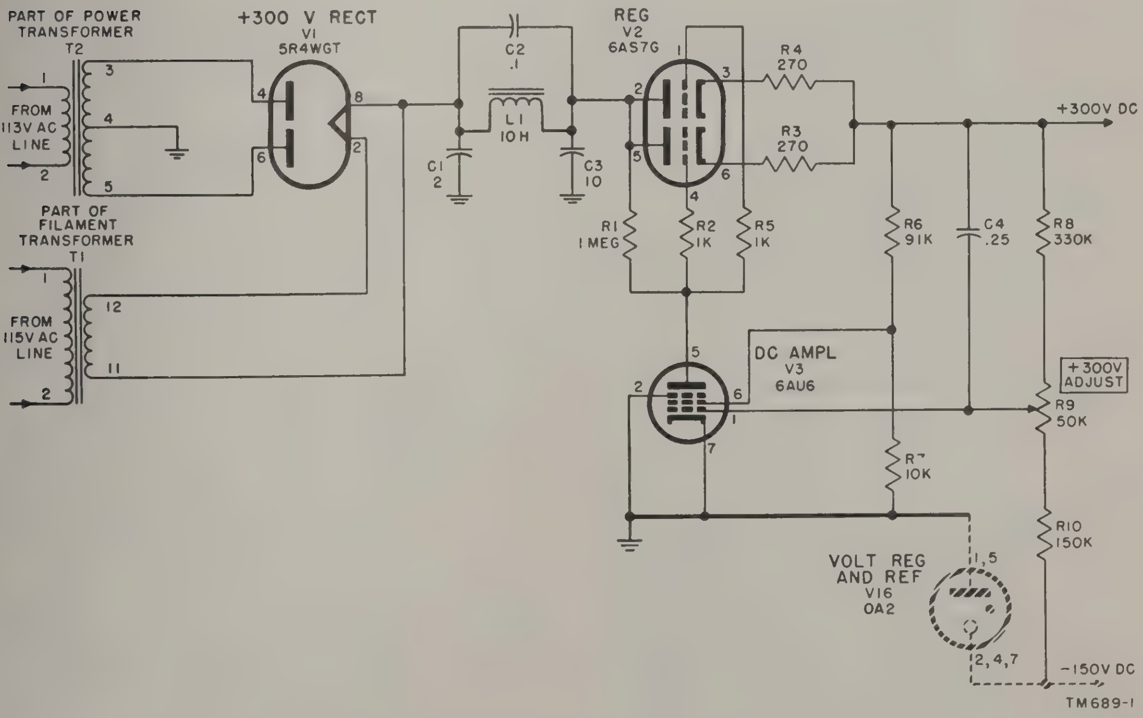

PART OF POWER TRANSFORMER T2
FROM 113V AC LINE
PART OF FILAMENT TRANSFORMER T1
FROM 115V AC LINE
+300 V RECT V1 5R4WGT
C2 .1
L1 10H
C1 2
C3 10
REG V2 6AS7G
R4 270
R3 270
R1 1 MEG
R2 1K
R5 1K
R6 91K
C4 .25
R8 330K
+300V DC
DC AMPL V3 6AU6
+300V ADJUST
R9 50K
R7 10K
R10 150K
VOLT REG AND REF V16 OA2
1,5
2,4,7
-150V DC
TM689-1

Figure 210. +300-volt regulated supply V1 through V3, simplified schematic diagram.

(*b*) Changes in potential at the output of the supply result in proportional changes in the control grid-cathode voltage of dc control amplifier tube V3. The resultant changes in current through plate load resistor R1 change the plate voltage of tube V3, and hence the grid voltage of series regulator tube V2, through grid resistors R2 and R5. The changes in grid voltage of V2 change the impedance of this tube and the voltage drop across it in such a manner as to return the output voltage to the proper value.

(*c*) Screen-grid voltage for V3 is furnished by a tap on the voltage divider formed by R6 and R7, between +300 volts and ground. The output voltage is adjusted by the setting of potentiometer R9. Capacitor C4 transmits sharp transient voltage changes directly to the grid of V3, which improves the response of the regulator.

(*d*) The effect of the action described in (*b*) above can be seen by analyzing a change in line voltage. An increase in line voltage increases the output voltage of rectifier tube V1. This raises the plate voltage and hence the cathode voltage of series regulator tube V2. Raising the cathode voltage of this tube increases the voltage drop across the output voltage divider. Since the low end of this divider is held constant by being returned to the —150-volt regulated supply, the voltage drop across each component of the divider increases. The resultant increase in the grid voltage of V3 through potentiometer R9 increases the current flow through this tube and, consequently, decreases its plate voltage. This decrease in plate voltage decreases the grid voltage of tube V2, resulting in an increased voltage drop across V2. The circuit parameters are chosen so that the increase in the voltage drop across tube V2 compensates for the rise in voltage applied at the plate of that tube. The net effect is to hold the output voltage constant at a level determined by the setting of +300 V ADJ potentiometer R9.

(2) *+250-volt regulated supply* (fig. 211).

(*a*) Type 5R4WGY tubes V4, V5, and V6 in parallel are connected in a full-wave rectifier circuit across a secondary winding of power transformer T2 to provide the necessary high voltage for both the +250- and +150-volt regulated outputs. The rectified output is taken at the filaments of the rectifiers and fed to a filter consisting of inductor L2 and capacitors C5 and C6. The output of this filter then is fed both to the +250- and the +150-volt regulator circuits.

(*b*) The +250-volt regulator circuit operates in the same manner as the +300-volt voltage regulator described in (1) above. Type 6AS7G series regulator tubes V7, V8, and V10A connected in parallel with each other provide the varying impedance whose changing voltage drop compensates for changes in output voltage. Because the regulator is in series with the load current, the added tubes are necessary to carry the load. Dc control amplifier V9, a 6AU6, sets the grid voltage of the series regulator tubes through resistors R13, R16, R17, R20, and R21, one for each triode section.

(*c*) The voltage divider across the output consists of resistors R25 and R27 and +250V ADJ potentiometer R26. The lower end of the voltage divider is returned to the —150-volt supply to provide a constant reference bias. Capacitor C7 improves the voltage regulator response to fast changes in output voltage. Resistors R23 and R24 form a voltage divider for obtaining proper screen-grid voltage on tube V9. Resistor R12 is the plate load for V9, and R14, R15, R18, R19, and R22 are the cathode resistors for regulator tubes V7, V8, and V10A.

(*d*) The circuit action is identical with that described for the +300-volt regulator ((1)(*d*) above).

(3) *+150-volt regulated supply* (fig. 212).

(*a*) The output of the filter consisting of inductor L2 and capacitors C5 and C6 (fig. 211) also is fed to the +150-volt regulator circuit through a 500-

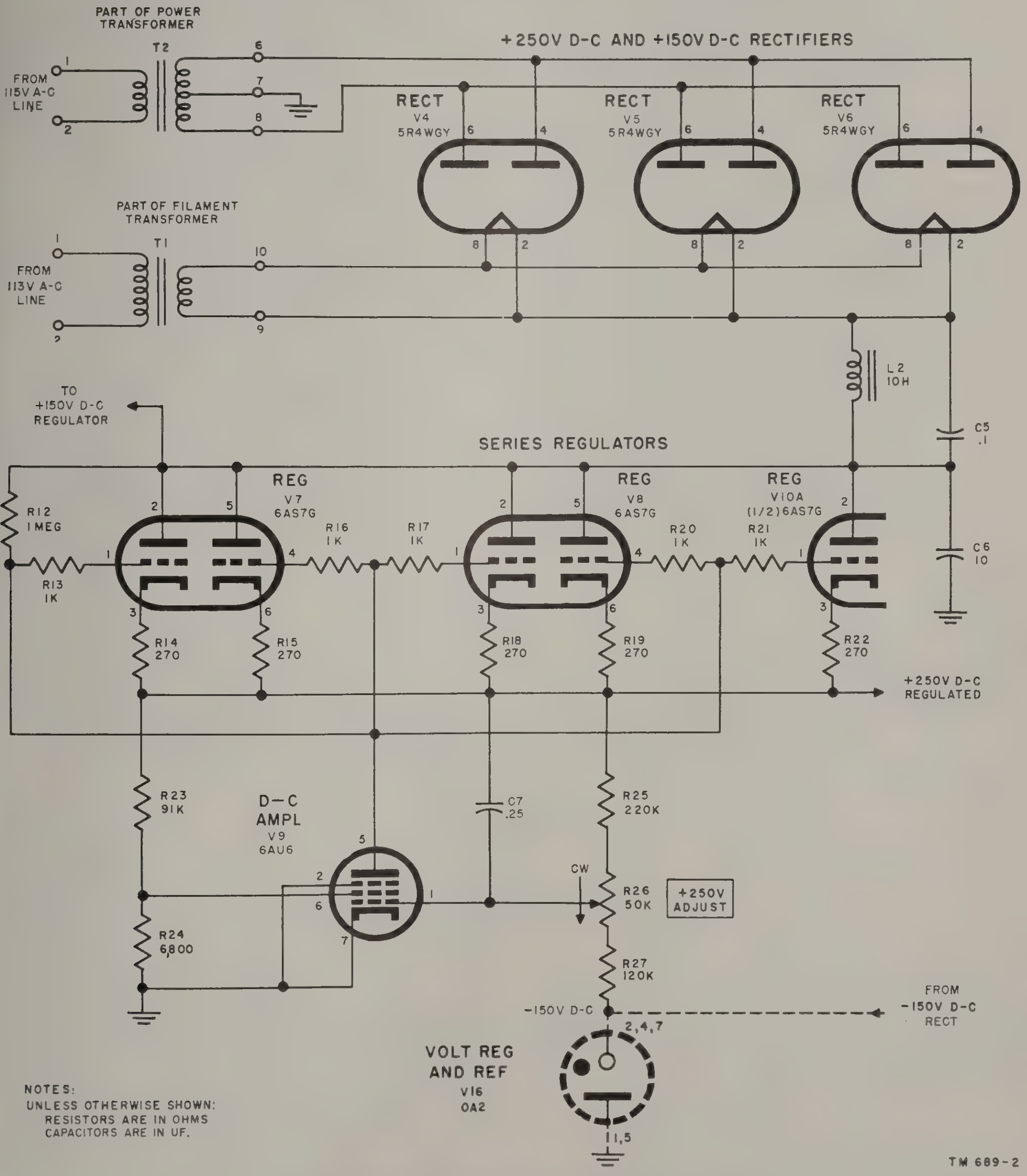

PART OF POWER TRANSFORMER
T2
FROM 115V A-C LINE
1
2
6
7
8
+250V D-C AND +150V D-C RECTIFIERS
RECT V4 5R4WGY
RECT V5 5R4WGY
RECT V6 5R4WGY
6
4
8
2
PART OF FILAMENT TRANSFORMER
T1
FROM 113V A-C LINE
10
9
L2 10H
C5 .1
C6 10
TO +150V D-C REGULATOR
SERIES REGULATORS
REG V7 6AS7G
REG V8 6AS7G
REG V10A (1/2)6AS7G
R12 1MEG
R13 1K
R16 1K
R17 1K
R20 1K
R21 1K
R14 270
R15 270
R18 270
R19 270
R22 270
+250V D-C REGULATED
R23 91K
R24 6,800
D-C AMPL V9 6AU6
C7 .25
R25 220K
CW
R26 50K
+250V ADJUST
R27 120K
-150V D-C
FROM -150V D-C RECT
VOLT REG AND REF V16 OA2
2,4,7
1,5
NOTES:
UNLESS OTHERWISE SHOWN:
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UF.
TM 689-2

Figure 211. ±250-volt regulated supply V4 through V10A, simplified schematic diagram.

ohm dropping resistor, R11 (fig. 212).

(b) The +250- and +150-volt regulators operate in an identical manner. The series regulator tubes are V11, V12, and V10B, all type 6AS7G. The dc control amplifier is V13, a type 6AU6. This tube sets the grid-voltage of the series regulators through grid resistors R29, R32, R33, R36, and R37.

(*c*) The voltage divider across the output consists of R41, R43, and +150V ADJUST potentiometer R42. The lower end of this voltage divider is returned to the —150-volt supply line to provide a constant reference bias for dc control amplifier V13. Capacitor C8 improves the voltage regulator response to fast changes in output voltage. Resistors R39 and R40 form a voltage divider for obtaining proper screen-grid voltage on tube V13. Resistor R28 is the plate load for V13, and R30, R31, R34, R35, and R38 are the cathode resistors for regulator tubes V11, V12, and V10B.

(*d*) The circuit action is identical with that described for the +300-volt regulator ((1)(*d*) above).

(4) *+42-volt regulated supply* (fig. 213).

(*a*) Part of the output of the +150-volt regulated supply is fed to the +42-volt voltage regulator. Shunt voltage regulator tube V14, a type OB2, and resistor R48 form a voltage divider across the +150-volt output, providing a regulated +42 volts at their junction.

(*b*) Capacitor C10 is a bypass capacitor for the circuits fed by the +42-volt supply. Resistor R44 is a transient-current limiter for the V14 circuit.

(*c*) Tube V14 maintains a constant voltage drop across itself by varying its resistance as the current through it changes. Since the +150-volt and ground potentials are constant, the voltage across R48 also is constant.

(5) *—150-volt regulated supply* (fig. 214).

(*a*) Rectifier tube V15, a 6X4W, is con-

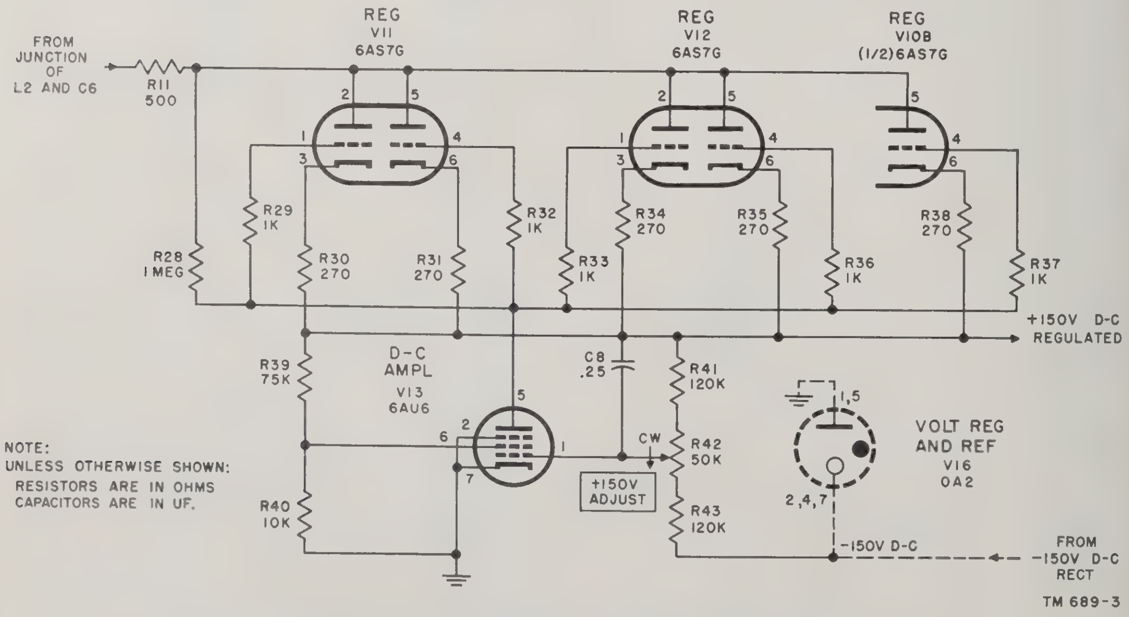

FROM JUNCTION OF L2 AND C6
R11 500
REG V11 6AS7G
REG V12 6AS7G
REG V10B (1/2)6AS7G
2
5
1
4
3
6
R28 1 MEG
R29 1K
R30 270
R31 270
R32 1K
R33 1K
R34 270
R35 270
R36 1K
R38 270
R37 1K
+150V D-C REGULATED
R39 75K
D-C AMPL V13 6AU6
C8 .25
R41 120K
CW
R42 50K
+150V ADJUST
R43 120K
R40 10K
1,5
VOLT REG AND REF V16 OA2
2,4,7
-150V D-C
FROM -150V D-C RECT
NOTE:
UNLESS OTHERWISE SHOWN:
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UF.
TM 689-3

Figure 212. +150-volt regulated supply V10B through V13, simplified schematic diagram.

nected in a conventional full-wave rectifier circuit across the secondary winding of power transformer T3. The cathode of V15 is returned to ground, and the negative rectified output is fed from the secondary winding center tap to an RC filter consisting of resistor R45 and capacitors C11 and C12.

(*b*) Resistor R46 in series with the output of the filter enables shunt voltage regulator tube V16, a type OA2, to maintain the output voltage constant. Capacitor C13 bypasses to ground any fast change in voltage. Resistor R47 is a bleeder resistor.

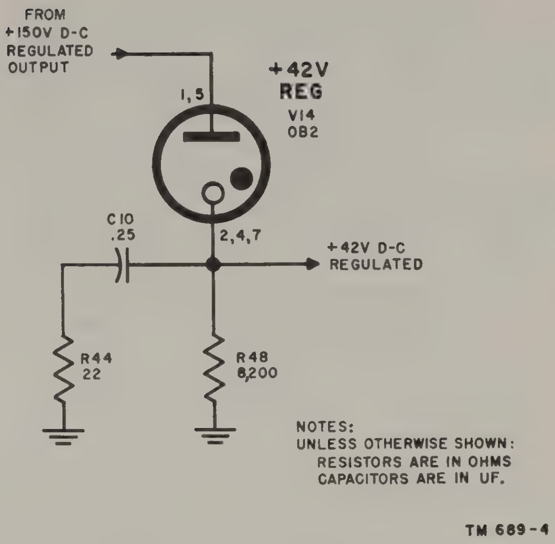

FROM +150V D-C REGULATED OUTPUT
+42V REG
V14
0B2
1,5
C10
.25
2,4,7
+42V D-C REGULATED
R44
22
R48
8,200
NOTES:
UNLESS OTHERWISE SHOWN:
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UF.
TM 689-4

Figure 213. +42-volt regulated supply V14, simplified schematic diagram.

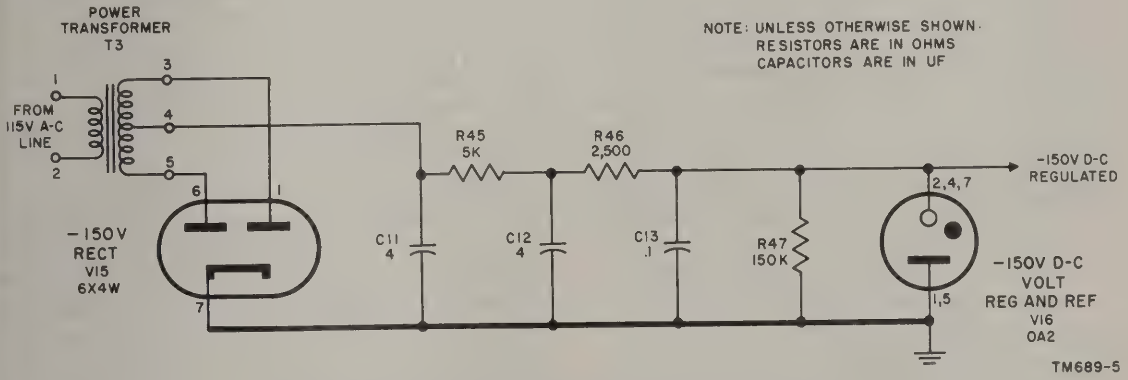

POWER TRANSFORMER T3
FROM 115V A-C LINE
1
2
3
4
5
6
1
7
-150V RECT
V15
6X4W
NOTE: UNLESS OTHERWISE SHOWN
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UF
R45
5K
R46
2,500
C11
4
C12
4
C13
.1
R47
150K
2,4,7
1,5
-150V D-C REGULATED
-150V D-C VOLT REG AND REF
V16
OA2
TM689-5

Figure 214. —150-volt regulated supply V15 and V16, simplified schematic diagram.

Section III. RECEIVING EQUIPMENT

174. General Description
(fig. 215)

a. General. The receiving equipment of Radio Set AN/TRC-29 consists of three separate units that have the following nomenclature:

(1) Radio Receiver R-418/G.
(2) Order Wire Receiver R-543/TRC-29.
(3) Power Supply PP-690/G.

b. Radio Receiver R-418/G.

(1) The primary function of Radio Receiver R-418/G is to accept fm, rf signals received by the antenna, amplify and demodulate them and furnish an output consisting of a multiplexed video signal and a 6-mc order-wire subcarrier.

(2) Signals received by the antenna are fed to the receiver input, in some cases through a duplexer. A duplexer is a device, constructed of passive circuit

elements, that permits one antenna to be used for both transmitting and receiving purposes on a frequency-sharing basis. The receiver is a single superheterodyne type, using a crystal-controlled local oscillator. It has a 120-mc intermediate frequency. The rf bandwidth of the receiver is approximately 21 mc; its video frequency response is limited by a filter in the order-wire receiver to slightly less than 6.0 mc. The rf circuits in the receiver are designed to cover frequencies from 1,700 to 2,400 mc.

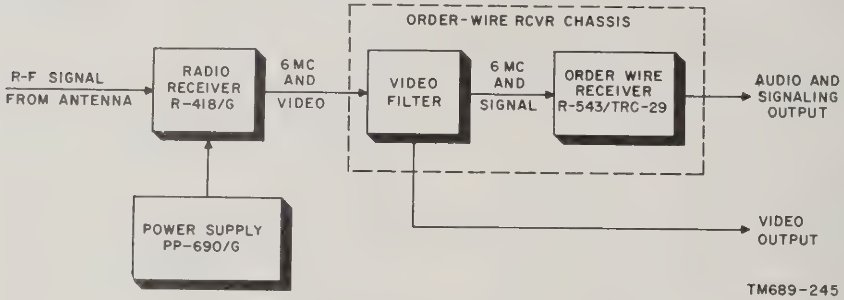


Figure 215. Receiving equipment, block diagram.

(3) The receiver has a preselector-mixer assembly, a local-oscillator assembly, an if. preamplifier, an if. amplifier, which includes limiting and demodulating circuits, and a video amplifier. In addition, it contains auxiliary operating circuits, including afc to maintain the local-oscillator frequency constant, and automatic gain control (agc) to insure a constant output level from the if. amplifier. The receiver also contains built-in test circuits to expedite alinement, troubleshooting, and evaluation of the performance of the equipment during operation. These test circuits feed pertinent signal voltages and currents to a meter panel that monitors a number of different critical signals on two meters by the use of suitable switching circuits. A functional block diagram description of the radio receiver is given in paragraph 175. Paragraphs 176 through 183 give detailed information on the components comprising the receiver.

c. Order-Wire Receiver R–543/TRC–29. The primary function of the order-wire receiver is to amplify and detect the 6-mc order-wire subcarrier and to furnish outputs that consist of the order-wire audio voltages, ringing and alarm signals. The order-wire receiver chassis contains a composite video filter, used to separate the video signal from the 6-mc order-wire subcarrier. This video filter contains two functional sections. One section acts as a low pass filter for the main video signal and presents an extremely high impedance to the 6-mc subcarrier. Therefore, only the video signal appears at the output of this section, and from there it is fed to the VIDEO OUTPUT receptacle. The other section of the filter presents a low impedance to the subcarrier signal and an extremely high impedance to the main video signal. Only the subcarrier signal appears at the output of this section, and this signal is applied to the subcarrier amplifier of the order-wire receiver. Auxiliary circuits in the order-wire receiver provide for connecting a local or remote handset for originating order-wire messages; for monitoring and alarm features; for the connection of transfer control equipment; and for the operation of sensing and control circuits for diversity operation. A dc power supply is an integral part of the unit. Details of the order-wire receiver are covered in paragraphs 184 through 189.

d. Power Supply PP–690/G. Power Supply PP–690/G furnishes six regulated voltages, covering all of the high- and low- frequency dc power requirements of Radio Receiver R–418/G. It contains high-voltage and low-voltage rectifier circuits and six regulator circuits. The regulated dc output voltages furnished are +250 volts, +150 volts, +42 volts, −300 volts, −475 volts, and −625 volts. In addition, the supply provides 6.3 volts ac for all tube heaters in the radio receiver and 115 volts ac for operation of the order-wire receiver. For detailed information on this power supply, refer to paragraph 190.

175. Radio Receiver R–418/G, Block Diagram
(fig. 216)

a. The rf input to the receiver is fed to a preselector that rejects any signal outside the selected receiver operating frequency range. The output of the preselector is fed to a crystal mixer where it is mixed with the output of klystron oscillator V21, whose frequency is adjusted to be 120 mc above that of rf input signal. The 120-mc intermediate frequency obtained at the output of the crystal mixer then is amplified by an if. preamplifier that contains six if. stages (V1–V6) and then by an if. amplifier containing six additional if. amplifiers (V7–V12). The output of the if. amplifier is fed through two limiters (V13 and V14) to a discriminator (V15) that detects the video and 6-mc order-wire subcarrier signals. These signals are amplified by a video preamplifier (V16) and video amplifiers V17 through V20. Agc is provided by means of a dc amplifier (V29) that adjusts the grid bias on one of the if. amplifiers (V7).

b. A portion of the klystron oscillator output is fed to the afc circuits, which stabilize the klystron output at the desired frequency. This portion of the klystron output is mixed with the output of a crystal-controlled oscillator-multiplier (V22–V24). A 34.5-mc intermediate frequency is obtained at the output of this mixer (CR3) which is amplified by 34.5-mc afc if. amplifiers V25 and V26, limited by V27 and fed to a discriminator (CR4 and CR5). The discriminator output is a positive or negative dc signal if the klystron frequency deviates from the desired frequency. This dc error voltage is amplified by the afc dc amplifier (V28) and is applied to the klystron reflector, changing its operating frequency in a direction that decreases the error signal. In this manner, the klystron frequency is stabilized at the desired frequency. A wavemeter receives a small portion of the klystron oscillator output for frequency-measuring purposes.

c. Suitable metering leads are connected from key points in the radio receiver circuits to the meter panel. Two meters are mounted on the meter panel with appropriate switching facilities to select the circuit to be metered.

176. Preselector Mixer Assembly

a. General. The signal picked up by the antenna is fed through a duplexer (in some installations), and through a coaxial cable to the preselector. The inner conductor of the coaxial cable is terminated in a loop formed within the first section of the preselector. The preselector consists of two high-Q cavities, each of which is tuned to the receiver frequency by means of a tuning rod driven by a tuning drive mechanism. These two cavities act as a narrow band-pass filter that passes only signals at the receiver frequency and rejects all other signals. At 1,715 mc, the filter has a maximum insertion loss of only 3 db over a bandwidth of approximately 21 mc (fig. 217). The signals passed by the preselector cavity are introduced into the crystal mixer, Z2, where they are mixed with the local-oscillator signal. The difference frequency (if.) of 120 mc is used to feed the if. preamplifier.

b. Detailed Description.

(1) *Preselector Z1.*

(*a*) Figure 218 is a simplified electromechanical diagram and figure 219 is the electrical equivalent circuit of the preselector and mixer assembly. The rf energy is coupled into the first cavity of the preselector by means of a coupling loop. Coupling between cavities is effected by an aperture located in the wall separating the two cavities. The cavity output is picked up by another loop and fed to the mixer.

(*d*) The cavities are tuned to the proper resonant frequency by a tuning drive mechanism, which increases or decreases the depth of insertion of the hollow tuning rods into the cavities. Each cavity must be tuned

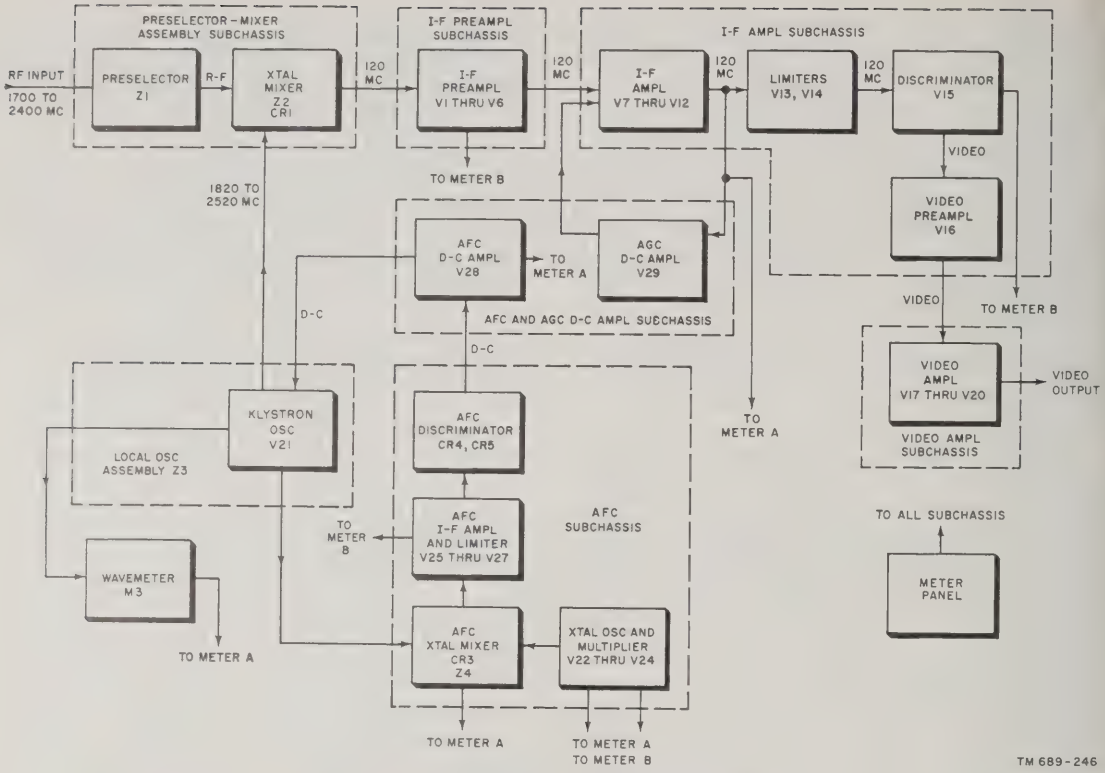

PRESELECTOR - MIXER ASSEMBLY SUBCHASSIS
I-F PREAMPL SUBCHASSIS
I-F AMPL SUBCHASSIS
RF INPUT
1700 TO 2400 MC
PRESELECTOR Z1
R-F
XTAL MIXER Z2 CR1
120 MC
I-F PREAMPL V1 THRU V6
120 MC
I-F AMPL V7 THRU V12
120 MC
LIMITERS V13, V14
120 MC
DISCRIMINATOR V15
VIDEO
TO METER B
1820 TO 2520 MC
VIDEO PREAMPL V16
AFC D-C AMPL V28
TO METER A
AGC D-C AMPL V29
AFC AND AGC D-C AMPL SUBCHASSIS
D-C
VIDEO
TO METER B
D-C
KLYSTRON OSC V21
LOCAL OSC ASSEMBLY Z3
AFC DISCRIMINATOR CR4, CR5
TO METER A
VIDEO AMPL V17 THRU V20
VIDEO OUTPUT
VIDEO AMPL SUBCHASSIS
TO METER B
AFC I-F AMPL AND LIMITER V25 THRU V27
AFC SUBCHASSIS
TO ALL SUBCHASSIS
WAVEMETER M3
METER PANEL
AFC XTAL MIXER CR3 Z4
XTAL OSC AND MULTIPLIER V22 THRU V24
TO METER A
TO METER A
TO METER A
TO METER B
TM 689-246

Figure 216. Radio Receiver R–418/G, block diagram.

separately, making sure that there is no interaction between it and the other cavity. For this purpose, detuning rods are placed inside the tuning rods. Normally, these detuning rods are withdrawn so that they are entirely within the tuning rods. During the tuning procedure, one detuning rod is pushed forward until a portion of the detuning rod extends beyond the ends of the tuning rod. This effectively detunes that cavity, permitting independent tuning of the other cavity. The insertion of the tuning rods can be varied by one of two driving mechanisms. The main tuning drive mechanism (fig. 218) drives both rods simultaneously. The primary rod is also driven by a separate driving mechanism, not shown on the simplified diagram, correcting for any tracking error.

(2) *Crystal mixer Z2.*

(*a*) The output of the second preselector cavity is fed into crystal mixer Z2. Also injected into the mixer through a 240-ohm isolating resistor is the output of the klystron local oscillator. The klystron frequency is adjusted to be 120 mc above that of the incoming rf signal. Consequently, an if. signal of 120 mc is obtained in the crystal mixer. This 120-mc if. signal is coupled out of the mixer assembly by means of a coaxial cable.

(*b*) As indicated in figures 218 and 219, the rf energy is prevented from reaching the if. output by means of an rf bypass capacitor and an rf choke. The rf bypass capacitor is

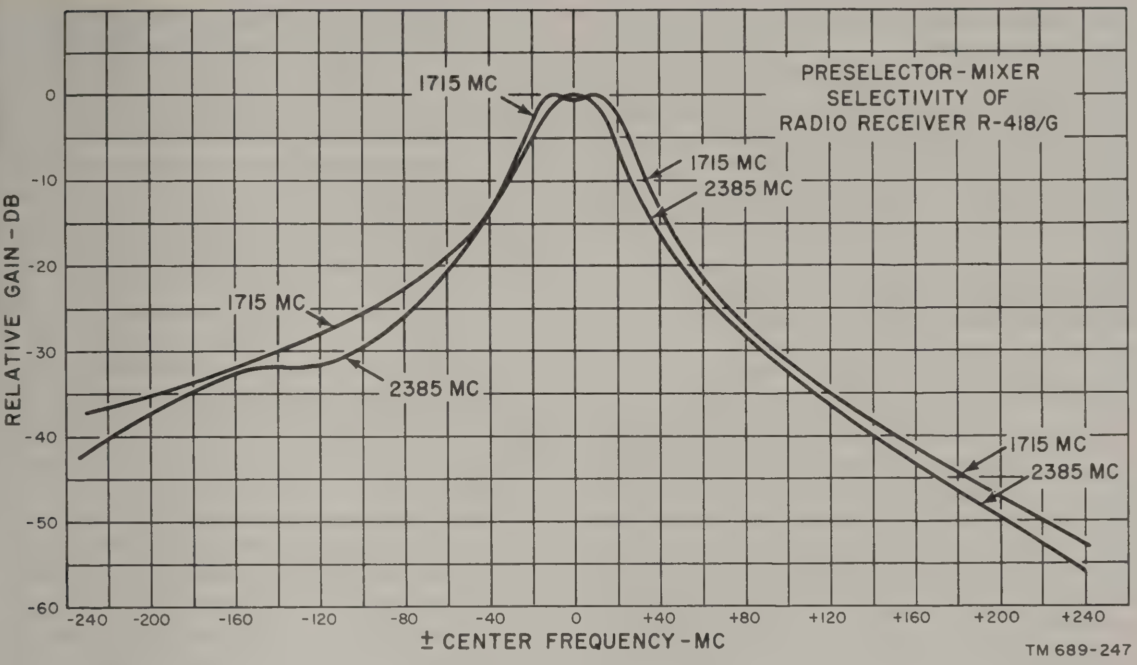


Figure 217. Preselector mixer selectivity curve.

formed by placing a dielectric between the crystal cathode and the sidewall of the assembly. The rf choke is a section of transmission line built around the if. output coupling. At its input it presents a very high impedance to rf energy, but a relatively low impedance to the if. energy. The if. signal appearing at the output of the mixer is transmitted to the if. preamplifier by a double-shielded coaxial cable. This coaxial cable is approximately ½ wavelength at the if. and serves to match the if. impedance of the crystal to the input impedance of the if. preamplifier, and this permits the physical separation of the mixer and if. preamplifier by a distance up to ½ wavelength.

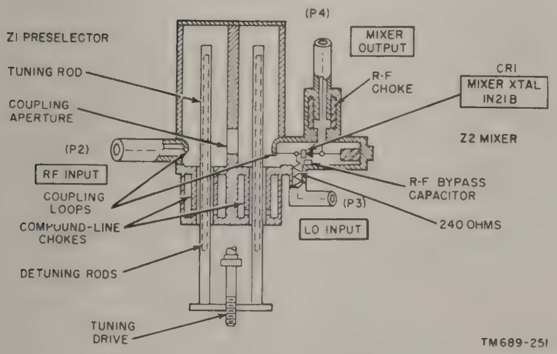

Z1 PRESELECTOR
TUNING ROD
COUPLING APERTURE
(P2)
RF INPUT
COUPLING LOOPS
COMPOUND-LINE CHOKES
DETUNING RODS
TUNING DRIVE
(P4)
MIXER OUTPUT
R-F CHOKE
CR1
MIXER XTAL IN21B
Z2 MIXER
R-F BYPASS CAPACITOR
(P3)
LO INPUT
240 OHMS
TM689-251

Figure 218. Preselector mixer Z1 and Z2 electromechanical diagram.

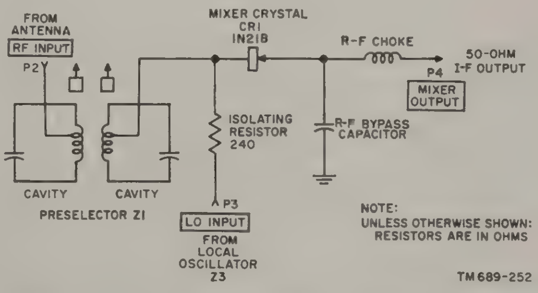

FROM ANTENNA
RF INPUT
P2
MIXER CRYSTAL
CR1
IN21B
R-F CHOKE
50-OHM I-F OUTPUT
P4
MIXER OUTPUT
ISOLATING RESISTOR 240
R-F BYPASS CAPACITOR
CAVITY
CAVITY
PRESELECTOR Z1
P3
LO INPUT
FROM LOCAL OSCILLATOR Z3
NOTE:
UNLESS OTHERWISE SHOWN:
RESISTORS ARE IN OHMS
TM689-252

Figure 219. Preselector mixer, electrical equivalent circuit.

177. Local-oscillator Assembly Z3 and Wavemeter M3

a. General. Local-oscillator assembly Z3 consists of two major parts, klystron oscillator tube V21, a 6BM6, and the reflex cavity in which it is installed. It is tunable over the range of 1,820 to 2,520 mc and provides a signal 120 mc above the frequency range of the transmitter. The oscillator furnishes three separate probe-coupled outputs, one to crystal mixer Z2, one to wavemeter M3, and another to afc mixer Z4.

b. Circuit Description.

(1) Since it is assumed that the reader is familiar with the basic fundamentals of reflex klystron operation, these are not covered in this manual. For detailed information on this subject, refer to TM 11–673. An electromechanical diagram of the local-oscillator assembly is given on figure 220.

(2) The cathode, or beam electrode, of V21 is connected to the —300-volt supply through a small current metering resistor, located in the afc and agc dc amplifier subchassis. The control-grid bias voltage is adjustable within the range of —300 to —475 volts dc by means of the BEAM CURRENT potentiometer, also in the afc and agc dc amplifier subchassis. The cavity grid, or anode, of the tube, is tied to ground, as is the positive side of the voltage supply. The reflector electrode is connected to a voltage that is negative with respect to the cathode. This voltage may be adjusted through the range —300 to about —600 volts depending on the frequency desired, and is controlled by the afc circuit for any one setting under operating conditions.

c. Operational Details.

(1) *Frequency-controlling elements.* Oscillation in the tube is sustained within the output cavity. The frequency of oscillation is primarily a function of the reflector voltage and the setting of the klystron cavity plunger. Also, it is affected to a small extent by the control-grid voltage. The klystron

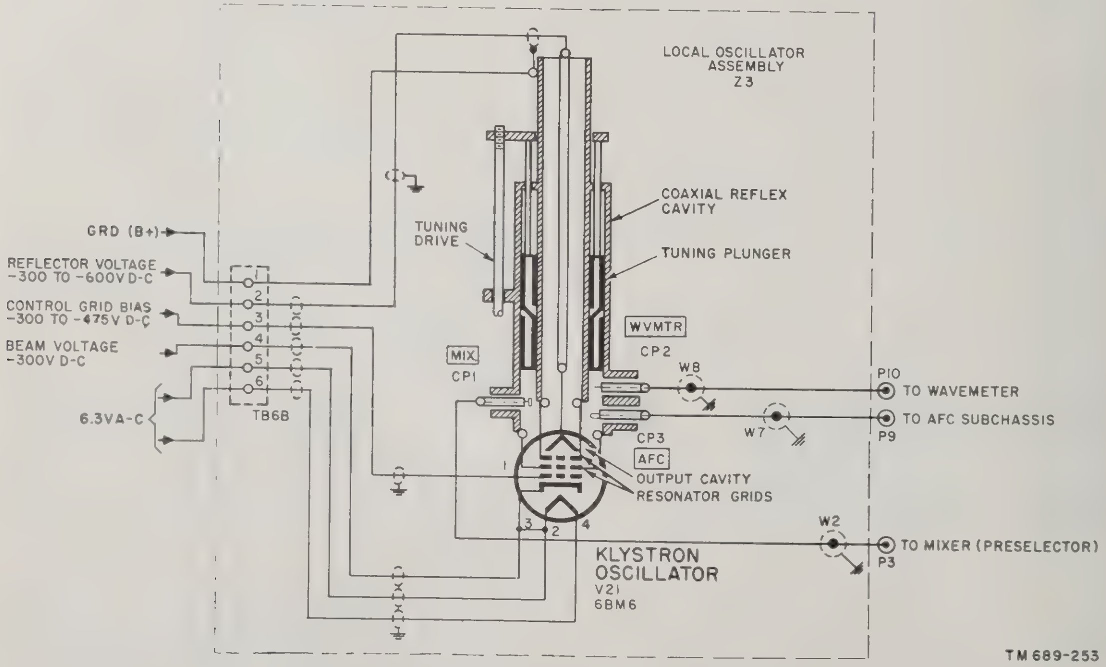

LOCAL OSCILLATOR
ASSEMBLY
Z3
COAXIAL REFLEX
CAVITY
TUNING PLUNGER
TUNING
DRIVE
GRD (B+)
REFLECTOR VOLTAGE
-300 TO -600V D-C
CONTROL GRID BIAS
-300 TO -475V D-C
BEAM VOLTAGE
-300V D-C
6.3VA-C
1
2
3
4
5
6
TB6B
MIX
CP1
WVMTR
CP2
W8
P10
TO WAVEMETER
TO AFC SUBCHASSIS
P9
W7
CP3
AFC
OUTPUT CAVITY
RESONATOR GRIDS
1
3
2
4
W2
TO MIXER (PRESELECTOR)
P3
KLYSTRON
OSCILLATOR
V21
6BM6
TM 689-253

Figure 220.—Local-oscillator assembly 23, electromechanical diagram.

plunger is adjusted initially to set the klystron near the desired frequency with the afc circuit disconnected. The reflector voltage then is adjusted by means of REFL V control on the afc and agc dc amplifier subchassis to provide the exact frequency desired. The control-grid voltage is adjusted to provide the proper beam current. These voltage controls are located in the afc dc amplifier in the afc and agc dc amplifier subchassis. With the afc system connected, any klystron oscillator frequency drift is corrected by automatic readjustment of the reflector voltage to bring the oscillator back on frequency.

(2) *Output probes.* The microwave energy developed in the klystron cavity is fed through coupling probes to three points: the rf crystal mixer, the afc subchassis, and the wavemeter. The physical configuration of the coupling probe varies for each of these outputs to provide the required power output. The crystal mixer probe is a small capacitive disk; the afc probe is in the form of a loop. For the wavemeter, the probe is merely an extension of the center conductor of the output cable into the cavity. All probes are coupled loosely into the cavity and load it very lightly. Consequently, they do not materially affect the klystron frequency.

(3) *Output signals.*

(*a*) The main oscillator output is obtained at CP1, MIX, and fed through cable W2 and plug P3 to the LO INPUT jack on mixer Z2, in which it is heterodyned with the rf signal.

(*b*) The afc output signal leaves the oscillator through afc probe CP3 and cable W7, which is connected through P9 to the LO INPUT jack on the afc subchassis. The signal is mixed with the afc crystal multiplier output to form the afc if., which is used to develop a frequency-correcting voltage.

(*c*) The rf energy picked up by the wavemeter probe, CP2, is fed through coaxial cable W8 and plug P10 to the wavemeter, M3. The wavemeter is illustrated on figure 160 and described in paragraph 165c(4). The wavemeter dc output is fed through P11 and a cable to METER A on the meter panel, where it is used to indicate the oscillator frequency.

Note. For Radio Receiver R–418/G on Order No. 1640–Phila–51 (serial No. 57–297) and Order No. 15739–Phila–55 (serial No. 298–417), a 470-ohm resistor has been added in the crystal output cable connector to reduce stray rf pickup. This resistor is part of the wavemeter assembly.

178. Afc Circuit

a. General. The klystron oscillator frequency is stabilized at the desired value by means of the afc circuit. This circuit is composed of the afc subchassis and the afc dc amplifier, located in the afc and agc dc amplifier subchassis. In the afc subchassis, the klystron output is compared with the output of a crystal-controlled signal. Any deviation in the difference frequency from the present value is amplified and applied as a dc voltage to the klystron reflector to correct the error.

b. Block Diagram Description (fig. 221). Tube V22 is a cathode-coupled crystal oscillator that develops an output in the frequency range between 44 and 53 mc. The second half of V22 doubles this frequency. This doubled output is passed through another frequency doubler and then through a third doubler (V23 and V24), which results in a signal ranging between 352 and 424 mc. The 5th or 6th harmonic of this signal, as required, is mixed in crystal mixer CR3 with a portion of the local-oscillator klystron output, which results in a difference, or intermediate frequency of 34.5 mc. The multiplied crystal frequency is always below the local-oscillator frequency. The intermediate frequency is amplified by three if. amplifiers, V25, V26, and V27. Some limiting action also takes place in V27, the output of which is fed to a discriminator composed of two crystal diodes. If the klystron frequency is correct, the discriminator output is zero. If the klystron frequency shifts, the discriminator output is a dc signal (positive or negative) proportional to the frequency shift, whose polarity depends on the direction of the shift. This dc signal is amplified by afc dc amplifier, V28, and applied with proper polarity and magnitude to the klystron reflector to correct for the frequency error.

c. Detailed Circuit Description.

(1) *Afc subchassis.*

(*a*) *Crystal oscillator-doubler, V22* (fig. 222).

1. The crystal oscillator-doubler, V22, uses a 2C51 twin triode, and operates in a range of 88 to 106 mc (doubled frequency), depending on the crystal used. The crystal frequency range is about 44 to 53 mc. The oscillator is a conventional cathode-coupled feedback circuit with crystal Y1 connected between the two cathodes of V22. The crystal acts as a low-impedance feedback path at its resonant frequency. Coil L45 is tuned to the fundamental frequency of the crystal while L46 is tuned to the 2d harmonic. The crystal frequency (within the range of 44 to 53 mc) is selected so that its multiplied output at the mixer is 34.5 mc below that of the assigned klystron frequency.

2. Tube V22A is a grounded-grid amplifier with a tuned plate circuit, which consists of L45 and C127. Capacitor C128, the rf bypass capacitor, also forms a part of the tuned circuit. However, because its capacitance is much greater than C127, it has very little reactance and the tuned circuit frequency is determined by C127. Resistor R175 is placed across coil L45 to lower its Q and

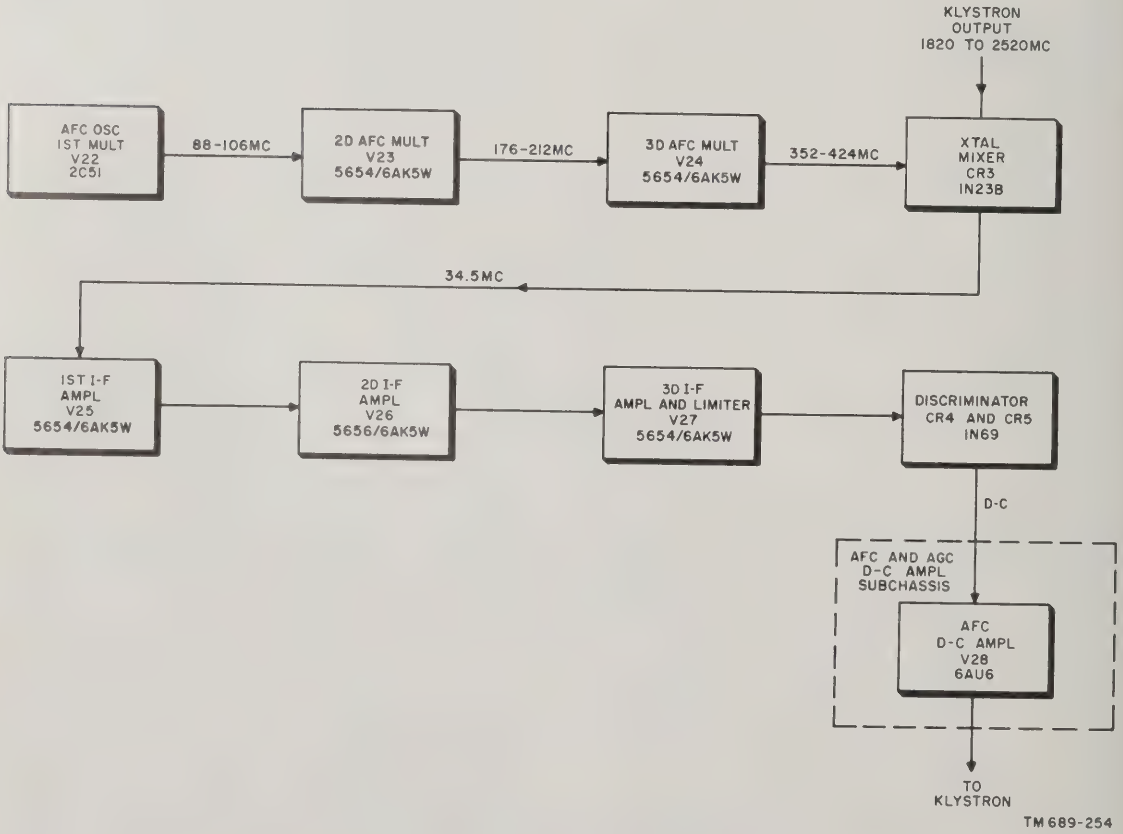

KLYSTRON OUTPUT 1820 TO 2520MC
AFC OSC IST MULT V22 2C51
88-106MC
2D AFC MULT V23 5654/6AK5W
176-212MC
3D AFC MULT V24 5654/6AK5W
352-424MC
XTAL MIXER CR3 IN23B
34.5MC
IST I-F AMPL V25 5654/6AK5W
2D I-F AMPL V26 5656/6AK5W
3D I-F AMPL AND LIMITER V27 5654/6AK5W
DISCRIMINATOR CR4 AND CR5 IN69
D-C
AFC AND AGC D-C AMPL SUBCHASSIS
AFC D-C AMPL V28 6AU6
TO KLYSTRON
TM 689-254

Figure 221. Afc circuit, block diagram.

to reduce the feedback driving voltage applied to the grid of V22B; this reduces the crystal dissipation. Resistor R103 is a plate-voltage dropping resistor and R102 is a parasitic suppressor. Capacitors C126 and C128 are rf bypass capacitors.

3. The rf voltage developed across the plate circuit of V22A is coupled through capacitor C125 to the grid of V22B. The voltage developed across cathode resistor R98 of V22B is coupled across cathode resistor R97 of V22A through crystal Y1. At the fundamental frequency, the two cathodes are in phase and the voltage feedback is greater then the input voltage across R97; consequently, the circuit is regenerative.

4. A low-impedance feedback path is provided by the quartz crystal exactly at its series-resonant frequency. The overall circuit gain is maximum at this frequency. The cathode-to-cathode impedance is high for all other frequencies in the vicinity of the crystal resonant frequency, while the plate-circuit gain is low at frequencies greatly removed from the resonant frequency. Therefore, oscillation occurs only at the series-resonant frequency of the crystal. A neutralizing coil, L44, in series with capacitor C123, is placed across the crystal to resonate any residual reluctance because of the crystal and crystal holder, further insuring that a high series impedance is presented to all frequencies other than the series-resonant frequency of the crystal.

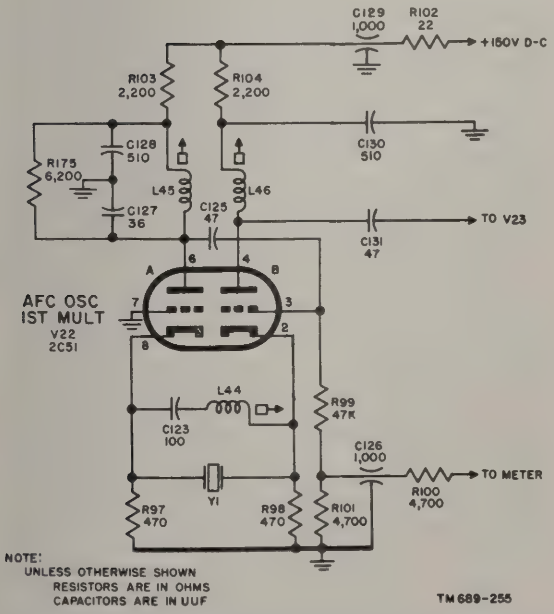

C129
1,000
R102
22
+150V D-C
R103
2,200
R104
2,200
C128
510
C130
510
R175
6,200
L45
L46
C127
36
C125
47
TO V23
C131
47
A
B
6
4
7
3
2
8
AFC OSC
1ST MULT
V22
2C51
L44
R99
47K
C123
100
C126
1,000
TO METER
R100
4,700
Y1
R97
470
R98
470
R101
4,700
NOTE:
UNLESS OTHERWISE SHOWN
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UUF
TM 689-255

Figure 222. Crystal oscillator-doubler V22, simplified schematic diagram.

5. Tube V22B also is a frequency doubler. The plate load that consists of L46 and its distributed capacitance is tuned to the 2d harmonic of the crystal frequency in the range of 88 to 106 mc. The voltage developed across this resonant circuit is applied to the grid of V23 through capacitor C131. Resistor R104 is a plate-voltage dropping resistor. Resistor R99 is the grid resistor, and R101 in the grid circuit together with R100 provides the proper voltage level to the meter circuit. Capacitors C130, C129, and C126 are rf bypass capacitors.

(*b*) *Second frequency doubler, V23* (fig. 223). The output of V22B is fed to V23, a 5654/6AK5W pentode, operated as a frequency doubler in the range of 176 to 212 mc. The plate circuit inductor of this stage, L47, is resonated with C134 in series with the tube capacitance to twice the freqency of the signal applied to its grid. Resistors R110 and R109 are voltage dropping resistors for the plate and screen, respectively. Resistor R106 is the grid resistor, whereas R108 provides the proper voltage to the meter circuit through resistor R107. Capacitors C132 and C133 are rf bypass capacitors.

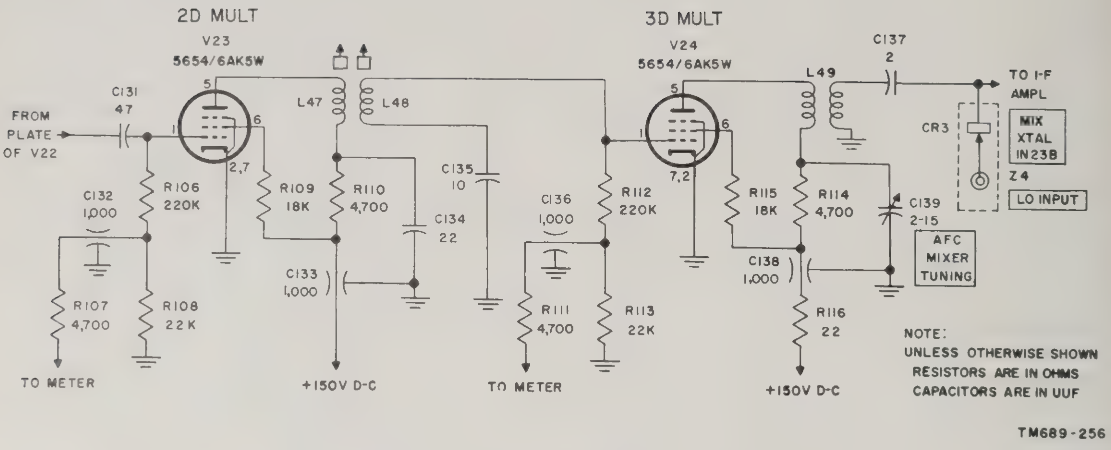

2D MULT
V23
5654/6AK5W
FROM PLATE OF V22
C131
47
5
1
6
2,7
L47
L48
C135
10
C132
1,000
R106
220K
R109
18K
R110
4,700
C134
22
C133
1,000
R107
4,700
R108
22 K
TO METER
+150V D-C
3D MULT
V24
5654/6AK5W
5
1
6
7,2
C136
1,000
R112
220K
R111
4,700
R113
22K
TO METER
L49
C137
2
TO I-F AMPL
CR3
MIX XTAL IN23B
Z4
LO INPUT
R115
18K
R114
4,700
C139
2-15
AFC MIXER TUNING
C138
1,000
R116
22
+150V D-C
NOTE:
UNLESS OTHERWISE SHOWN
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UUF
TM689-256

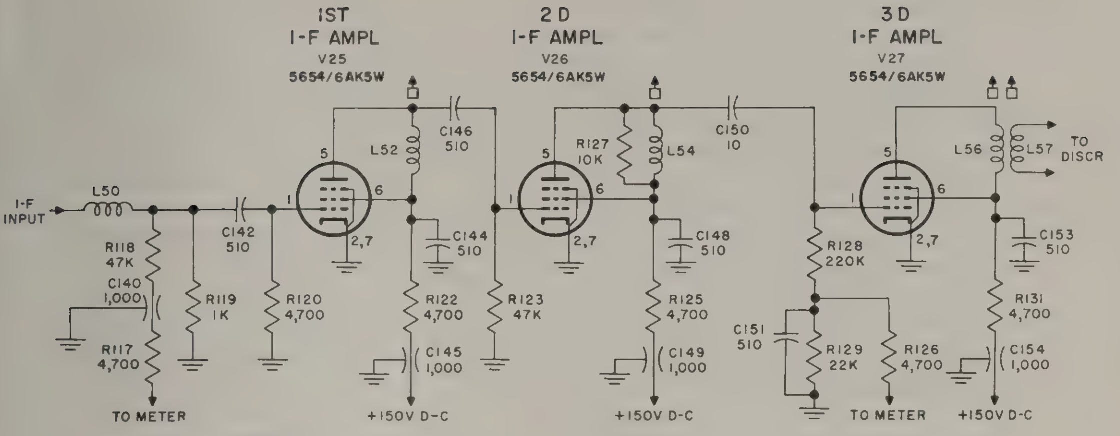
Figure 223. Second and third doublers V23 and V24, and mixer CR3, simplified schematic diagram.

(*c*) *Third frequency doubler, V24* (fig. 223). The voltage developed across L47 is coupled inductively to L48, which resonates at the same frequency as L47, and the signal is applied to the grid of V24, the third frequency doubler. The resonant circuit of L48 includes C135 and the input capacitance of V24. This stage develops an output in the frequency range of 352 to 424 mc across the tuned plate circuit comprised of L49, C139, and the capacitance of the tube. Resistors R115 and R114 are voltage dropping resistors for the screen and plate, respectively, and R116 is a parasitic suppressor. Resistor R112 is the grid resistor, and R113 provides the proper voltage to the meter current through resistor R111. Capacitors C136 and C138 are rf bypass capacitors.

(*d*) *Crystal mixer (CR3) Z4* (fig. 223). The output of V24 is coupled inductively through L49 (primary and secondary wound on a common form) to the crystal mixer, which serves as both a mixer and harmonic generator. As a harmonic generator, the crystal provides a harmonic frequency (of the 352- to 424-mc output) in the frequency range of 1,785.5 to 2,485.5 mc. Many harmonic frequencies are developed in this stage; however, only that frequency is used that is 34.5 mc below the assigned frequency of the klystron. In the lower half of the band, the 5th harmonic of the V24 output is selected, while in the upper part of the band, the 6th harmonic is used. All other harmonics and sum and difference frequencies are rejected by the if. amplifier following the mixer. The klystron output is fed to the crystal through a coaxial cable. Rf bypassing is provided by the capacitance that exists between the crystal cathode and outer shell of the housing. A dc path to ground for the crystal is provided by L50 and R119 in the input circuit of the if. amplifier (fig. 224).

(*e*) *34.5-mc if. amplifier V25 through V27* (fig. 224).

1. The 34.5 mc if. signal obtained from the crystal mixer is amplified by three stages of if. amplification, V25 through V27, all type 5654/6AK5W pentodes. The crystal mixer output is coupled to the grid of V25 through L50 and C142. Conductor L50 serves to reject any rf energy component in


1ST
I-F AMPL
V25
5654/6AK5W
2 D
I-F AMPL
V26
5654/6AK5W
3 D
I-F AMPL
V27
5654/6AK5W
I-F
INPUT
L50
R118
47K
C140
1,000
R117
4,700
TO METER
C142
510
R119
1K
R120
4,700
1
5
6
2,7
L52
C146
510
C144
510
R122
4,700
C145
1,000
+150V D-C
R123
47K
R127
10K
L54
C150
10
C148
510
R125
4,700
C149
1,000
+150V D-C
R128
220K
C151
510
R129
22K
R126
4,700
TO METER
L56
L57
TO
DISCR
C153
510
R131
4,700
C154
1,000
+150V D-C

NOTE:
UNLESS OTHERWISE SHOWN
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UUF

TM689-257

Figure 224. Afc if. amplifiers V25 through V27, simplified schematic diagram

the mixer output. Resistor R119 in series with L50 provides a dc return path for the crystal. The crystal mixer current is metered through meter resistors R118 and R117. Capacitor C140 is an if. bypass capacitor.

2. The first if. amplifier, V25, is resonated at 34.5 mc by distributed capacitance inductor L52 in its plate circuit (fig. 224). Resistor R122 in the plate circuit is a voltage dropping resistor and C144 and C145 are if. bypass capacitors. Resistor R120 is the grid resistor. The output of V25 is fed through capacitor C146 to the grid of V26, the second if. amplifier. This if. amplifier is similar to the first one, except that R127 is connected across resonant coil L54 to lower the Q of the circuit. Resistor R123 is the grid resistor, R125 the plate- and screen-voltage dropping resistor, and C148 and C149 are if. bypass capacitors. Inductor L54 and the distributed capacitance also resonate at 34.5 mc.

3. The output of V26 is fed to the 3d if. amplifier, V27, through coupling capacitor C150. This stage also acts as a limiter. The grid voltage in this stage is metered through the grid resistor voltage-divider network of R128 and R129 and meter resistor R126. The plate circuit is resonated at 34.5 mc by coil L56 and the distributed capacitance. Resistor R131 is the plate- and screen-voltage dropping resistor, and C151, C153, and C154 are if. bypass capacitors.

(*f*) *Discriminator, CR4 and CR5* (fig. 225).

1. The output of the if. amplifier is coupled capacitively through capacitor C155 and inductively through inductor L57 to the discriminator circuit. The discriminator uses two 1N69 germanium diodes, CR4 and CR5, in a balanced ungrounded circuit. The voltage applied to each crystal is the resultant, E_r, of the voltage applied to the circuit through C155 and that applied through L57. The output voltage is equal to the difference between the two resultant voltages.

2. To describe the basic principles of this discriminator, it is necessary to define certain basic vectors that exist in the circuit. Inductors L56 and L57 are coupled inductively and together with their circuit capacitances comprise the tuned primary and secondary of the discriminator transformer. The voltage that appears across the primary, L56, is designated E_1. The voltage inductively coupled and appearing across the secondary, L57, is designated E_1'.

3. The secondary voltage E_1' is referenced to the primary voltage E_1 by connecting L56 through C155 to the center point of the secondary tuned circuit of L57 and two *equal* capacitors C156 and C157. At resonance, E_1' is —90° (—90°, rather than +90°, by design of the transformer) out of phase with E_1. Voltage E_1' may be represented by two voltages, designated E_2 and E_3. Voltage E_2 is measured from the center of the secondary tuned circuit to the top of L57 and appears across C157. Voltage E_3 is measured from the center of the tuned circuit to the bottom of L57 and appears across C156. These two voltages, E_2 and E_3, are always equal and 180° out-of-phase. All of these vectors and their relationship to each other are shown in figure 226.

4. The phase of E_1 with respect to E_1' is a function of the applied signal frequency. When the applied signal frequency is 34.5 mc, the resonant circuit that consists of L57 and C156 and C157 acts as a pure resistance and introduces no reactance into the circuit. Under this condition, as indicated above, E_1' is exactly —90° (270°) out of phase with E_1.

5. The voltage with respect to reference point A, figure 225 obtained at the junction of C157 and CR4 is equal to the vectorial sum of E_1 and E_2. This vectorial sum, designated $E_{r1,2}$, is shown in B, figure 226 for the resonant condition

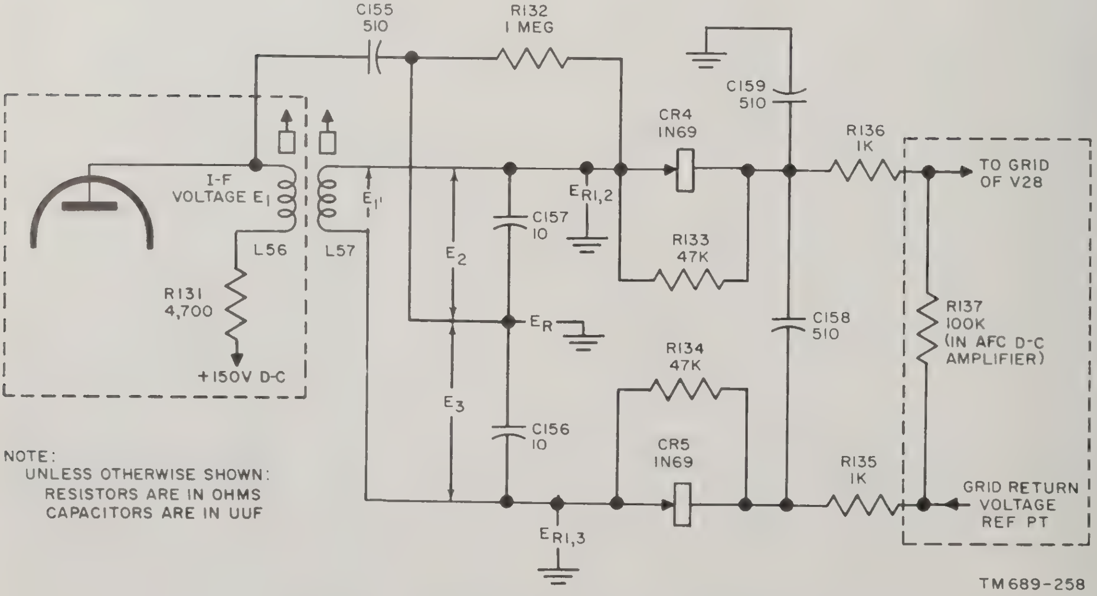
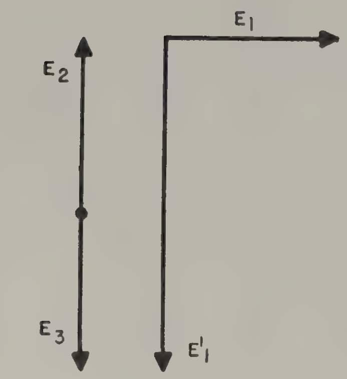
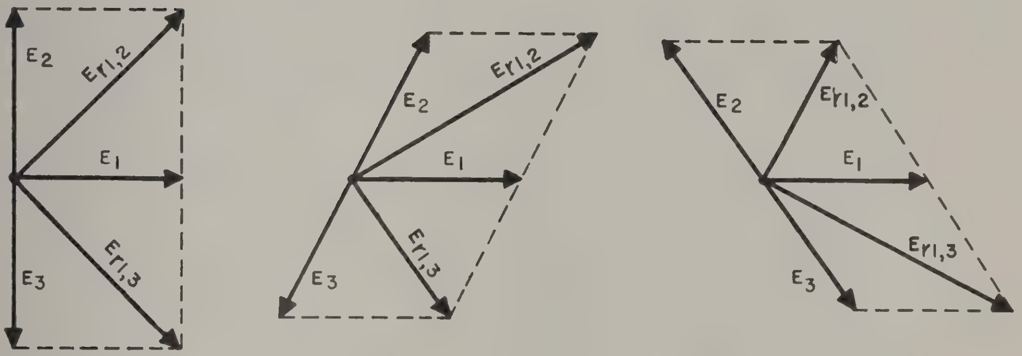

C155
510
R132
I MEG
C159
510
CR4
IN69
R136
IK
TO GRID
OF V28
I-F
VOLTAGE E1
E1'
ER1,2
C157
10
R133
47K
L56
L57
E2
R131
4,700
ER
C158
510
R137
100K
(IN AFC D-C
AMPLIFIER)
R134
47K
+150V D-C
E3
C156
10
CR5
IN69
R135
IK
GRID RETURN
VOLTAGE
REF PT
ER1,3
NOTE:
UNLESS OTHERWISE SHOWN:
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UUF
TM689-258

Figure 225. Afc discriminator CR4 and CR5, simplified schematic diagram.



A. DEFINITION OF VECTORS



B. RESONANCE

C. BELOW RESONANCE

D. ABOVE RESONANCE

TM 689-486

Figure 226. Afc discriminator vector diagram.

described in *4* above. Similarly, the voltage with respect to reference point A obtained at the junction of C156 and CR5 is the vectorial sum of E_1 and E_3, designated $E_{r1,\ 3}$ as shown in B, figure 226. $E_{r1,\ 2}$ is equal to $E_{r1,\ 3}$ when the applied signal is 34.5 mc.

6. When the applied signal frequency is below 34.5 mc, the resonant circuit introduces an inductive reactance component into the circuit. Consequently, the phase between E_1' and E_1 becomes less than —90°. As a result, the magnitude of $E_{r1,\ 2}$ increases and $E_{r1,\ 3}$ decreases (C, fig. 226).

7. Similarly, when the applied signal frequency is above 34.5 mc, the resonant circuit introduces a capacitive reactance component into the circuit causing the phase between E_1 and E_1' to increase above —90°. In this case, $E_{r1,\ 3}$ increases (D, fig. 226).

8. The resultant voltage $E_{r1,\ 2}$ is applied to crystal diode rectifier circuit comprised primarily of CR4, C158, R136, and R137. The time constant of C158, R136, R137, and

R135, is such that capacitor C158 charges up to the peak $E_{r1, 2}$ voltage when CR4 is conducting and discharges only slightly during the cutoff period. The voltage developed across C158 in this manner is positive with respect to reference point A.

9. The resultant voltage $E_{r1, 3}$ is applied to crystal diode rectifier circuit comprised of CR5, C158, R135, R137, and R136. In this case, a negative voltage with respect to reference point A is developed across C158 equal to the peak $E_{r1, 3}$ voltage. This voltage, of course, subtracts from the positive voltage developed across C158 from $E_{r1, 2}$.

10. When the applied signal is 34.5 mc, and $E_{r1, 2}$ is equal to $E_{r1, 3}$, the net voltage developed across C158 is zero, and hence the output of the discriminator is zero. When the applied signal is below resonance, $E_{r1, 2}$ is greater than $E_{r1, 3}$ and a net positive voltage is developed across C158. Similarly, when the applied signal frequency is above resonance, a net negative voltage is developed across C158. A typical measured frequency-versus-output voltage response curve is given on figure 227.

11. The input frequency is exactly 34.5 mc when the klystron is at its assigned frequency. If the klystron frequency increases, the crystal mixer output becomes greater than 34.5 mc and the output of the discriminator is a negative voltage. Conversely, if the klystron output frequency decreases, a positive voltage is obtained at the discriminator output. This output is fed to the afc dc amplifier.

12. Resistors R133 and R134 effectively reduce the backward resistance of CR4 and CR5 to about 47,000 ohms each and act as loading resistors for the resonant circuit. Also, without these two resistors the high backward resistance of CR4 might be considerably different from that of CR5, thereby unbalancing the circuit. When the equipment is switched from the ON position to the OFF position, a very large initial surge of voltage is applied to the discriminator. Resistor R132, 1-megohm, applies the direct high voltage, connected to the output of the discriminator during this initial surge, to the other side of capacitors C155, C156, and C157 to prevent breakdown during switching capacitor. Capacitor C159 is an if. bypass capacitor.

(2) *Afc dc amplifier V28* (fig. 228).

(*a*) Afc dc amplifier V28, located in the afc and agc dc amplifier subchassis, provides a correction signal to the klystron reflector when it is off frequency, and supplies proper klystron electrode voltages. Included in this stage is BEAM CURRENT potentiometer R145, which varies the bias voltage supplied to the control grid of the klystron. This is adjusted to limit the beam current to 15 ma.

(*b*) The reflector voltage obtained from the plate of V28 is a function primarily of the voltage drop across V28, a type 6AU6 pentode. The cathode of this stage is connected to the —625-volt supply through bias resistor R139. The plate is connected to —300 volts through R144 and R146. The reflector voltage can vary between a minimum of —300 volts when V28 is cut off and about —600 volts when the tube current is maximum.

(*c*) The exact output reflector voltage obtained in the absence of an afc correction signal or with switch S1 in the OFF position, depends on the setting of R146, the REFL V (reflector voltage) control. Resistor R146 varies the plate circuit resistance and plate supply voltage of V28 and consequently the plate voltage and reflector voltage.

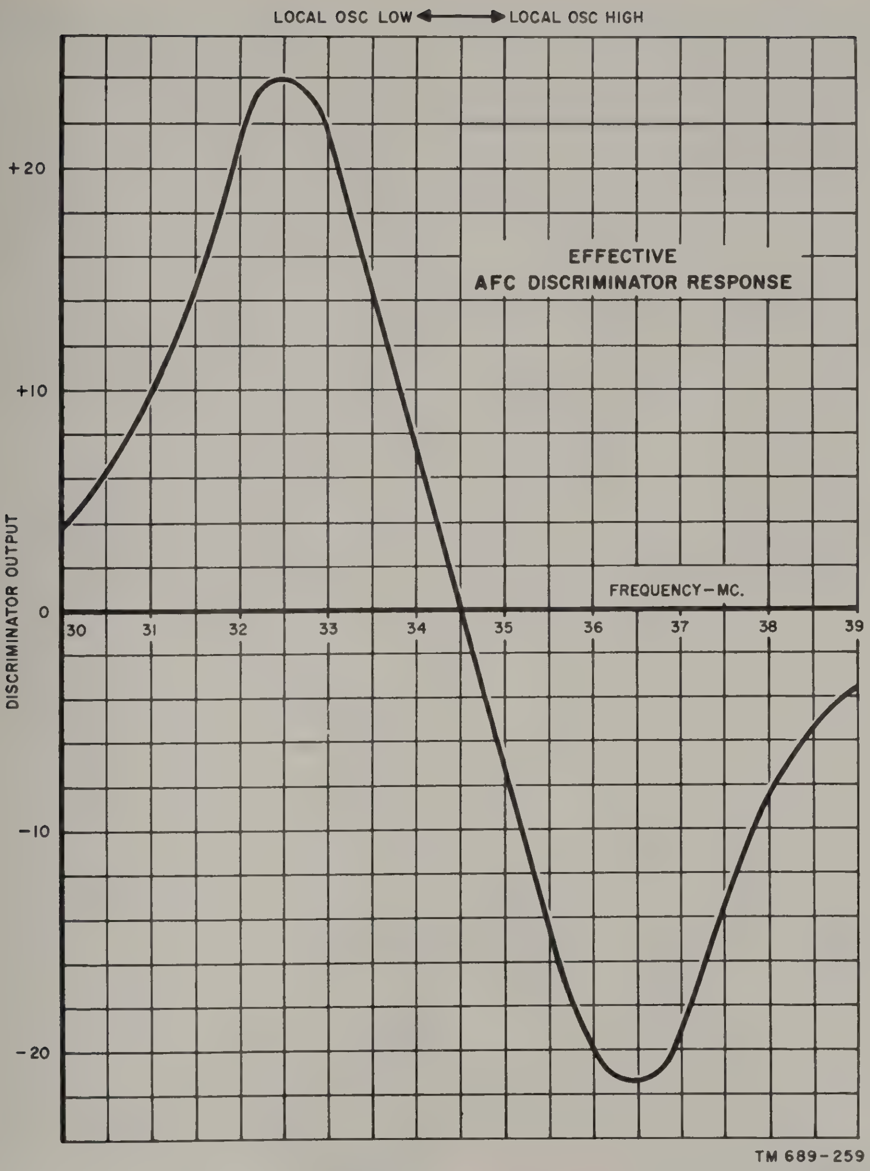


Figure 227. Afc discriminator response curve.

(*d*) When an afc error voltage is applied to this circuit, the circuit action varies the reflector voltage in the following manner. The error voltage is developed across resistor R137, and is fed to the grid of V28. When the error voltage on the grid is positive (with respect to the junction of R137 and R139, that is, reference point A), the total bias decreases, the tube draws current, the tube drop decreases and the reflector voltage becomes more negative (approaches —625 volts). This increases the klystron frequency. When the error voltage is negative, the voltage drop across V28 increases and the reflector voltage becomes more positive (or less negative), which decreases the klystron frequency.

(*e*) The cathode of V28 is tied to the —475-volt supply through resistor R141. The function of the —475-volt supply is to provide a bleeder current through R141 and R139 to the —625-volt supply, resulting in a fixed bias across R139. This results in a stable, fixed, quiescent current through V28 in the absence of input signal. All three negative supplies (—300, —475, —625 volts) are so designed that any voltage change that appears on the —625-volt supply is transmitted equally to the other supplies, which insures that all relative voltages are constant. Capacitor C160 across resistor R144 in the V28 plate circuit bypasses transient changes in plate voltage. The reflector voltage is metered through R143.

179. If. Preamplifier

a. General. The crystal mixer output is fed to the input of the if. preamplifier subchassis. This subchassis contains six if. amplifier stages, V1 through V6. The first two stages, V1 and V2, form a cascode circuit, the next three, V3 through V5, form a stagger-tuned triplet, and the 6th if. amplifier, V6, acts as a single amplifier stage, the output circuit of which is designed to match the input impedance of the coaxial coupling cable plus the if. amplifier input which this circuit drives.

b. Block Diagram Description (fig. 229).

(1) The first two if. amplifiers, V1 and V2, are types 5654/6AK5W and 6J4, respectively. They are connected in a circuit configuration known as the

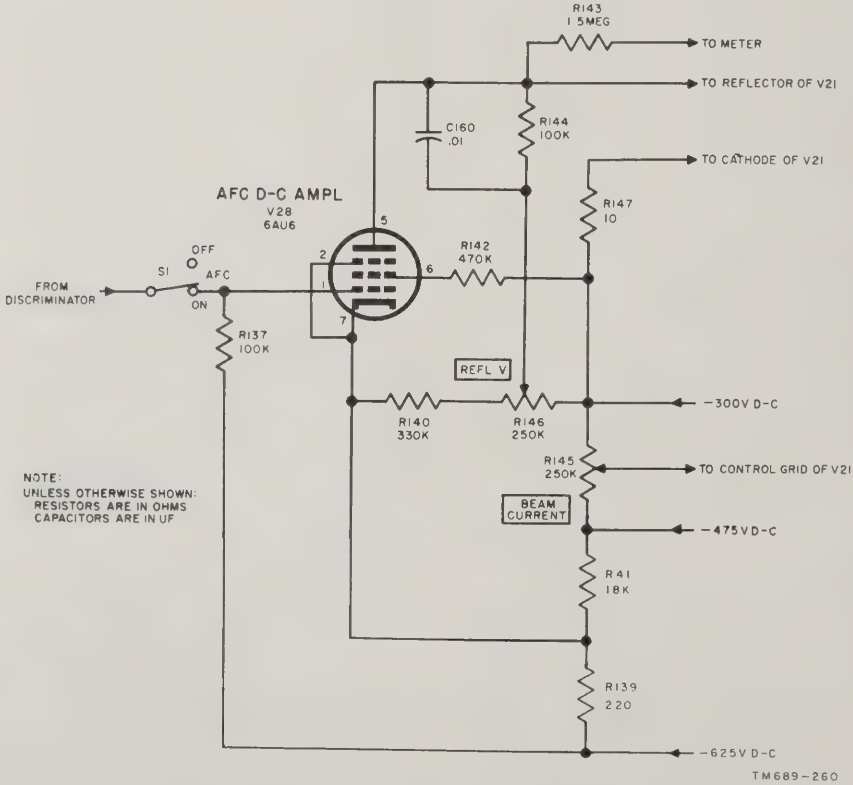

R143
1.5MEG
TO METER
TO REFLECTOR OF V21
C160
.01
R144
100K
TO CATHODE OF V21
AFC D-C AMPL
V28
6AU6
R147
10
5
OFF
2
R142
470K
6
S1
AFC
1
FROM
DISCRIMINATOR
ON
7
R137
100K
REFL V
-300V D-C
R140
330K
R146
250K
R145
250K
TO CONTROL GRID OF V21
NOTE:
UNLESS OTHERWISE SHOWN:
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UF
BEAM
CURRENT
-475V D-C
R41
18K
R139
220
-625V D-C
TM689-260

Figure 228. Afc dc amplifier V28, simplified schematic diagram.

cascode (not to be confused with *cascade*), which has many advantages in this type of application. In comparing the features of this circuit with that of other circuits, the two tubes and their associated circuitry are considered as one unit rather than two separate stages. The basic cascode circuit has two triodes. The first triode is connected in the conventional manner with its cathode grounded. The output from the plate of the first triode is fed to the cathode of the second triode, the grid of which is grounded. The output of the combination is obtained at the plate of the second triode. Resonant circuits are used as plate loads for both tubes. In this application, the 6AK5 tube used for V1 is triode-connected. This circuit arrangement combines the desirable features of both pentodes and triodes, while eliminating some of the undesirable features of each. It features the high-gain, high-impedance input, and stability of a pentode, but has the low noise figure of a triode, an important factor when amplifying weak signals at these frequencies. The improvement in noise figure over a more conventional pentode amplifier is approximately 2 db at 120 mc.

(2) The 3d, 4th, and 5th if. amplifiers, V3 through V5, are associated in what is called a stagger-tuned triplet. They are in cascade, and have conventional circuitry. Their main feature as a triplet is the fact that only one of the stages is tuned to the desired intermediate frequency. The other two are tuned, respectively, above and below the if. and are designed to have a Q about double that of the on-frequency stage. This results in a response curve which has a relatively flattop over a wide band of frequencies, giving a good gain-bandwidth product.

(3) The output from the triplet is fed to the 6th if. amplifier, V6, which further amplifies the signal and, at the same time, has a specially designed output circuit that acts as a reactive voltage divider, as well as an impedance-matching device for the cable that carries the preamplifier output signal to the if. amplifier.

c. Detailed Circuit Description.

(1) *Cascode amplifier, V1 and V2* (fig. 230).

(*a*) The basic principles and features of the cascode amplifier have been described in *b*(1) above. This cascode amplifier consists of the 5654/6AK5W 1st if. amplifier, V1, and the 6J4 2d if. amplifier, V2. The 120-mc if. signal from the output of crystal mixer, Z2, enters the if. preamplifier at the PRE IF. INPUT connector, and is coupled to the grid of V1 through the double-tuned pi-type if. transformer consisting of L1, L3, C3, and L4. Capacitor C3 is a coupling capacitor. Inductors L1 and L4 in combination with the input capacitance of V1, shown as Cgk on the figure, are alined for a broad pass band about a center frequency of 120 mc. The plate and screen grid of V1 are connected together (as are the cathode and suppressor grid), effectively giving a tube having triode characteristics. The output signal of V1 is developed across L7, which is tuned to 120 mc, and coupled to the cathode of V2 through

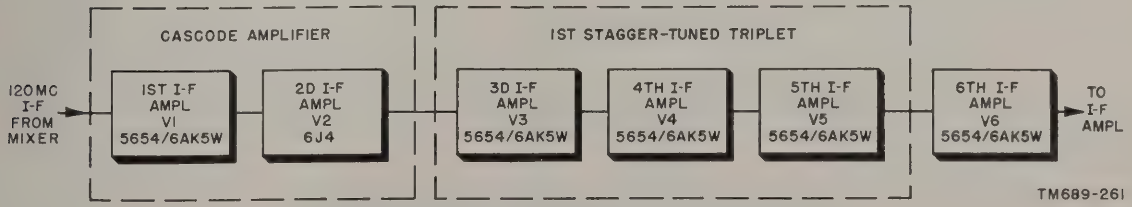

CASCODE AMPLIFIER
IST STAGGER-TUNED TRIPLET
120MC I-F FROM MIXER
IST I-F AMPL VI 5654/6AK5W
2D I-F AMPL V2 6J4
3D I-F AMPL V3 5654/6AK5W
4TH I-F AMPL V4 5654/6AK5W
5TH I-F AMPL V5 5654/6AK5W
6TH I-F AMPL V6 5654/6AK5W
TO I-F AMPL
TM689-261

Figure 229. If. preamplifier, block diagram.

C10. Inductor L6, resistor R4, and capacitor C9 are used as a neutralizing network. Neutralization is used here not primarily for stability considerations, but because it helps to improve the noise figure.

(*b*) The grid of V2, a 6J4, is grounded; the cathode signal is amplified and taken off at the plate. The output signal is coupled to the grid of V3 in the triplet by the T-type if. transformer formed by L9, L10, C16, and L11. Capacitor C16 is a coupling capacitor. Both coils are resonated with tube and distributed circuit capacitances to provide a broad pass band about a center frequency of 120 mc. Resistor R7 is placed across the primary of the double-tuned transformer to reduce the Q and broaden the pass band.

(*c*) Resistor R3 develops cathode bias for V1, bypassed by C4 and 7. Resistors R5 and R9 are plate-voltage dropping resistors for V1 and V2, respectively, while R6 and R8 are power supply decoupling resistors. If. bypass capacitors in this circuit also include C1, C2, C8, C11, C14, C15, and C17.

(*d*) In the input circuit, R2 provides a dc return path for the crystal mixer current. Coil L2 is an rf choke that prevents leakage of if. current from the meter circuit. The mixer current develops a voltage across R2, which is connected through R1 to METER B, which monitors the if. mixer crystal current.

(2) *First triplet, V3 through V5.*

(*a*) *Basic if. amplifier circuit.*

1. All three if. amplifier stages in the first triplet use identical circuits. Figure 231 is a simplified schematic diagram of the third if. amplifier (V3). Except for the use of different reference symbols for the component parts, this schematic diagram applies to the other if. amplifiers in the triplet.

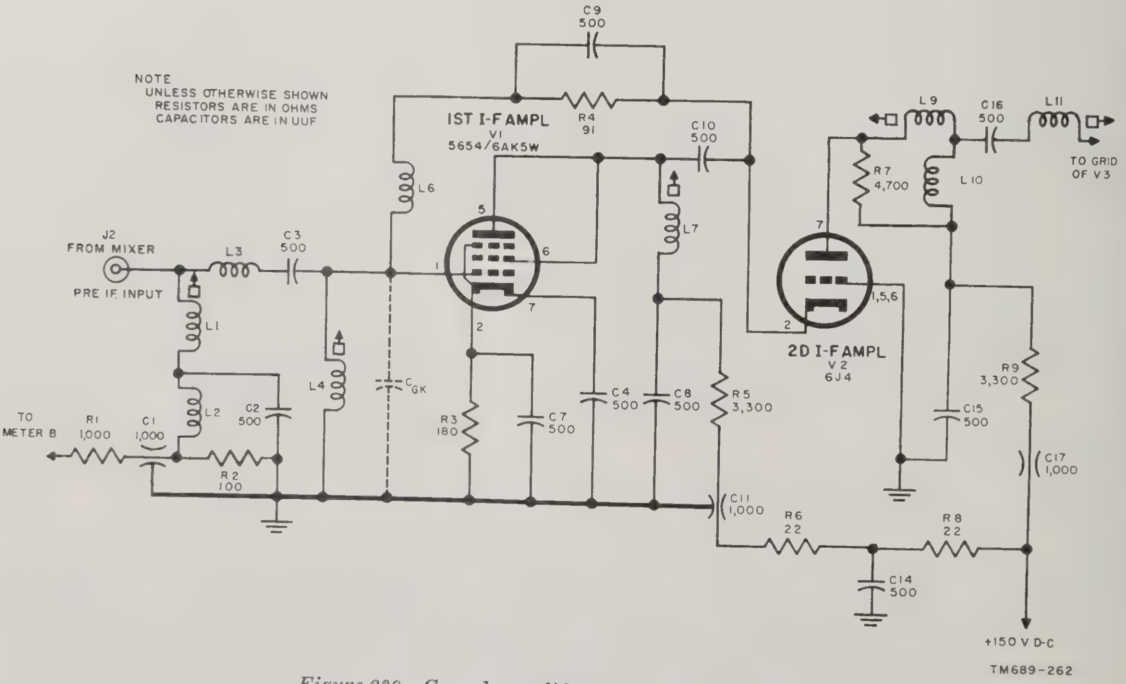

NOTE
UNLESS OTHERWISE SHOWN
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UUF
C9
500
R4
91
1ST I-F AMPL
V1
5654/6AK5W
C10
500
L6
L7
5
6
1
7
2
J2
FROM MIXER
PRE IF INPUT
L3
C3
500
L1
L2
C2
500
L4
C_{GK}
R3
180
C7
500
C4
500
C8
500
R5
3,300
TO
METER B
R1
1,000
C1
1,000
R2
100
C11
1,000
L9
C16
500
L11
TO GRID
OF V3
R7
4,700
L10
2D I-F AMPL
V2
6J4
1,5,6
R9
3,300
C15
500
C17
1,000
R6
22
R8
22
C14
500
+150 V D-C
TM689-262

Figure 230. Cascode amplifiers V1 and V2, simplified schematic diagram.

2. In the if. amplifier circuit on figure 231, the if. input signal is applied to the grid of V3, a 6AK5W pentode. The signal is amplified and appears across tuned coil L13, which is resonated with its own distributed capacitance and that of the tube at the frequency desired. Resistor R10 is the grid resistor, R12 is the cathode-biasing resistor, R15 isolates the stage if. from the B+ supply, and R13 provides additional decoupling and plate-voltage dropping. Capacitors C18, C19, C21, C22, and C23 are all if. bypass capacitors. Inductors L12 and C20 provide decoupling for the filament supply. Capacitor C24 is the output coupling capacitor.

(*b*) *V3 through V5, 3d, 4th, and 5th if. amplifiers.*

1. Tubes V3, V4, and V5, the 3d, 4th and 5th if. amplifiers are cascade-connected to form a circuit configuration known as a stagger-tuned triplet. A stagger-tuned triplet consists of three cascaded amplifiers with single-tuned coupling networks having Q's and resonant frequencies that yield a high overall gain-bandwith product (TM 11–667).

2. One stage is tuned to the nominal center frequency, one stage above this frequency, and one stage somewhat below the center frequency. The result gives a relatively flat response over a wide frequency band. In addition, to help compensate for the characteristic drop at the sides of a tuned circuit curve, the Q's of the stages tuned above and below the center frequency are adjusted to be about twice as high as the Q of the on-frequency stage. This also aids in *squaring* the response curve by giving a sharp dropoff at the sides. In this equipment, the Q of the high- and low-frequency stages is 11; the Q of the on-frequency stage is 5.5.

3. In the first triplet, 3d if. amplifier V3 is tuned to 130.5 mc, the 4th amplifier to 110.5 mc, and the 5th

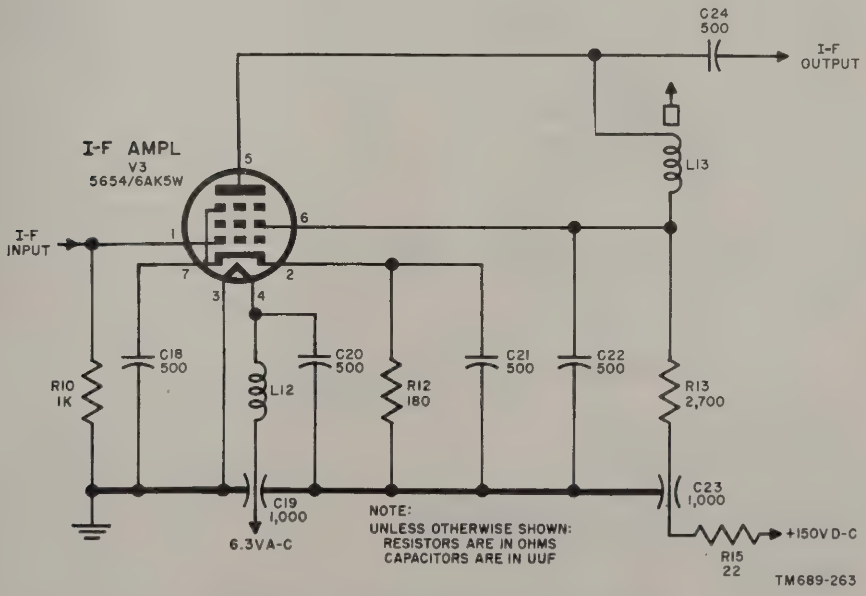

C24
500
I-F
OUTPUT
L13
I-F AMPL
V3
5654/6AK5W
5
6
I-F
INPUT
1
7
2
3
4
C18
500
C20
500
C21
500
C22
500
R10
1K
L12
R12
180
R13
2,700
C19
1,000
6.3VA-C
NOTE:
UNLESS OTHERWISE SHOWN:
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UUF
C23
1,000
+150V D-C
R15
22
TM689-263

Figure 231. Basic if. amplifier (V3), simplified schematic diagram.

amplifier to 120 mc. This arrangement provides an overall bandwidth of 21 mc and an overall gain of approximately 28 db. A complete schematic diagram is shown on figure 395. The output of this triplet is developed across L17 and coupled through C38 to the grid of V6.

(3) *V6, 6th if. amplifier* (fig. 232). The 6th if. amplifier, V6, a type 5654/6AK-5W, in addition to its amplification function, matches the impedance of the preamplifier output to the 93-ohm impedance of the coaxial cable that couples it to the if. amplifier input. The if. input signal to V6 is developed across grid resistor R22. The output voltage is fed to the reactive divider network that consists of L19, L20, and C47 in the plate circuit of V6. Inductor L19 is resonated with tube and distributed circuit capacitances to 120 mc, and the output signal is developed across the load L20 and C47 with the proper impedance transformation. Inductors L19 and L20 and capacitor C47 are actually part of a T-type transformer with the output series arm equal to zero. This output is coupled through C48 to J3, the PRE IF OUTPUT jack, where it enters the 93-ohm cable connecting it to the if. amplifier input. Resistor R24 is the cathode-biasing resistor, and R25 and R26 are the plate- and screen-voltage dropping and power supply decoupling resistors, respectively. Capacitors C40, C43, C44, C45 and C46 are if. bypass capacitors for the amplifier stage.

180. If. Amplifier

a. General (fig. 233). The if. signal from the output of the if. preamplifier is fed to the if. amplifier. Here the signal is amplified by six stages of if. amplification and then fed through two limiters to a discriminator. The output of the discriminator consists of a video signal (including the order-wire subcarrier), which is amplified by a video preamplifier and sent to the video

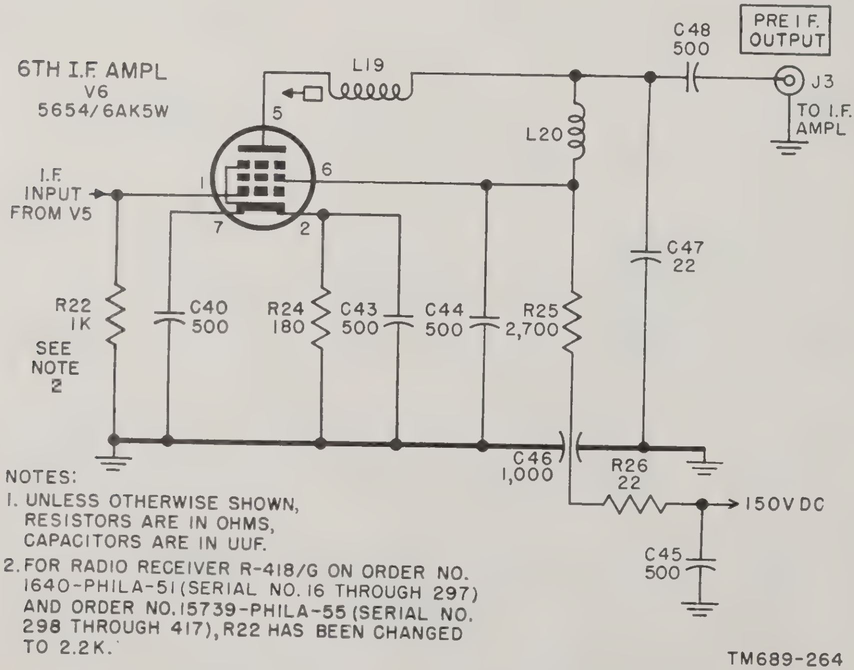

6TH I.F. AMPL
V6
5654/6AK5W
L19
C48
500
PRE I F.
OUTPUT
J3
TO I.F.
AMPL
L20
5
6
1
7
2
I.F.
INPUT
FROM V5
C47
22
R22
1K
SEE
NOTE
2
C40
500
R24
180
C43
500
C44
500
R25
2,700
C46
1,000
R26
22
150V DC
C45
500
NOTES:
1. UNLESS OTHERWISE SHOWN, RESISTORS ARE IN OHMS, CAPACITORS ARE IN UUF.
2. FOR RADIO RECEIVER R-418/G ON ORDER NO. 1640-PHILA-51 (SERIAL NO. 16 THROUGH 297) AND ORDER NO. 15739-PHILA-55 (SERIAL NO. 298 THROUGH 417), R22 HAS BEEN CHANGED TO 2.2K.
TM689-264

Figure 232. Sixth if. amplifier V6, simplified schematic diagram.

amplifier, and a dc signal, which is used for measurement purposes at the meter panel. The six if. amplifiers are arranged as two triplets, or triple stagger-tuned stages, comparable to the triplet in the if. preamplifier. The 7th, 8th, and 9th if. amplifiers comprise the second triplet (the first is in the if. preamplifier) and the 10th, 11th, and 12th if. amplifiers make up the third triplet. This subchassis is the same as the if. amplifier subchassis used in the transmitter. Part of the output of the 12th if. amplifier is rectified and sent through the agc (automatic gain control) amplifier; the agc amplifier feeds the signal back to the grid of the 7th if. amplifier where it determines the bias and, therefore, the gain of V7. The agc amplifier (*e* below), though electrically and functionally a part of the if. circuits, is located on the afc and agc dc amplifier subchassis.

b. Typical If. Amplifier Circuit. All six if. amplifier stages have identical circuitry, with the exception of the 12th if. amplifier, the output circuit of which is slightly different. This difference is explained in *d* below. These if. amplifier stages are identical with the basic if. amplifier circuit described in paragraph 179*c*(2)(*a*) (fig. 231) except for the use of reference symbols.

c. Second Triplet, V7 Through V9. Tubes V7, V8, and V9 (7th, 8th, and 9th if. amplifiers) (fig. 396) are cascaded to form the second triplet. The stagger-tuned triplet configuration is described in paragraph 179*c*(2). In this triplet, V7 is resonated at 130.5 mc, V8 at 120 mc, and V9 at 110.5 mc. The output of V9 is fed to V10 and a part of the third triplet.

d. Third Triplet, V10 through V12. Tubes V10, V11, and V12 (10th, 11th, and 12th if. amplifiers) are cascaded to form the third triplet. In this triplet, V10 is tuned to 130.5 mc, V11 to 110.5 mc, and V12 to 120 mc. Note that the output voltage of V12 is developed across plate-load resistor R52 instead of a coil, and resonance is effected by coil L32 in the input circuit of first limiter stage V13. Crystal CR2, in the input circuit of V13, detects a portion of the signal and develops a positive voltage across RC network R55 and C95 that is proportional to

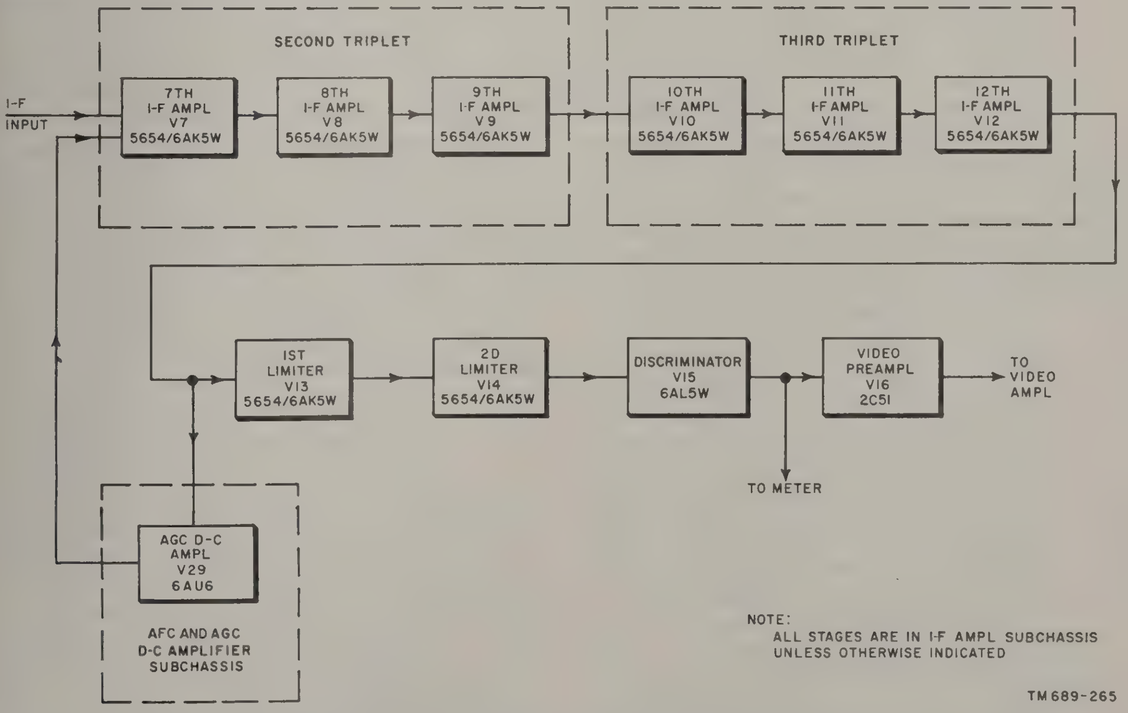

SECOND TRIPLET
THIRD TRIPLET
I-F INPUT
7TH I-F AMPL V7 5654/6AK5W
8TH I-F AMPL V8 5654/6AK5W
9TH I-F AMPL V9 5654/6AK5W
10TH I-F AMPL V10 5654/6AK5W
11TH I-F AMPL V11 5654/6AK5W
12TH I-F AMPL V12 5654/6AK5W
1ST LIMITER V13 5654/6AK5W
2D LIMITER V14 5654/6AK5W
DISCRIMINATOR V15 6AL5W
VIDEO PREAMPL V16 2C51
TO VIDEO AMPL
TO METER
AGC D-C AMPL V29 6AU6
AFC AND AGC D-C AMPLIFIER SUBCHASSIS
NOTE: ALL STAGES ARE IN I-F AMPL SUBCHASSIS UNLESS OTHERWISE INDICATED
TM 689-265

Figure 233. If. amplifier, limiters, discriminator, and video preamplifier, block diagram.

the amplitude of the incoming signal. This voltage is applied to the input of the agc dc amplifier in the afc and agc dc amplifier subchassis through resistors R53 and R54, to develop an agc voltage, which is used to control the gain of V7. Capacitor C94 is an if. bypass capacitor.

e. Agc Dc Amplifier V29 (fig. 234).

(1) The gain of the if. amplifier is automatically varied inversely with variations in signal level to maintain a constant output. This is accomplished by controlling the bias on 7th if. amplifier V7 by the action of agc dc amplifier V29, a 6AU6 pentode.

(2) The presence of a signal at the if. amplifier output (plate of V12) is detected by CR2, and a positive voltage developed across the RC network, consisting of R55 and C95, is applied through resistors R53, R54, and R148, and bypass capacitor C94, to the grid of V29. The voltage is amplified and inverted in the plate circuit of the tube and appears at the output as a *less positive* dc potential.

(3) The if. bias voltage is developed at the junction of R155, R153, and CR6. This voltage is the difference between the positive dc voltage existing at the plate of V29 because of the +150-volt supply, and a negative voltage obtained from the —625-volt supply, through a voltage divider comprised of R154, R155, R153, and R149. In the absence of an if. signal, the grid becomes more negative with respect to the cathode and V29 is biased beyond cutoff by the high fixed voltage applied to its cathode from the +150-volt supply through voltage-divider network R150, R151, and R152. Under this condition, the plate voltage of V29 is at its maximum positive value; the if. bias cannot rise above about +0.5 volt, which is the voltage drop across CR6 (the 1N69 germanium clipping diode), when a positive voltage is applied across it. The voltage cannot become more positive than this value because CR6 presents a low impedance above this voltage value. IF. LEVEL potentiometer R152 in the cathode circuit of V29 adjusts the sensitivity of the circuit.

(4) The output voltage is passed through R29 and R28 and applied to the grid of V7 in the if. amplifier. An increase in signal causes more plate current in V29, lowering the voltage at the junction of R149 and R153, and placing a more negative voltage on CR6. This causes V7 bias to increase in the negative direction. The stronger the if. signal, the more the negative increase in bias and the lower the amplification of V7. The gain of the if. amplifier is decreased as the signal strength increases, which causes the average output if. voltage level to be maintained approximately constant.

f. First Limiter V13 (fig. 235).

(1) The output of the 12th if. amplifier is coupled through C93 to first limiter V13, a 5654/6AK5W pentode. In this limiter, the cathode is grounded and a regulated +42-volt screen and plate voltage is used. This results in maintaining an essentially constant output level for both positive and negative half-cycles of the incoming if. signal to a level high enough to allow the limiter grid to be overdriven in both the positive and negative directions. In the positive direction, grid-saturation limiting occurs because the grid is driven positive, drawing grid current; limiting in the negative direction occurs because grid cutoff is reached. Coil L32 in the input circuit to this stage is resonated at 120 mc. Resistors R58 and R57 are plate- and screen-voltage dropping resistors and C98 is the screen if. bypass capacitor. Resistor R58, in conjunction with bypass capacitor C99, isolates the +42-volt supply from if. signals. Resistor R56 is a plate-load resistor. If. decoupling for the filament supply is provided by chokes and bypass capacitors in the filament line (not shown in simplified schematic diagrams).

(2) Inductors L34, L36, and L35, in conjunction with associated tube capacitances, comprise a wide-band tuned

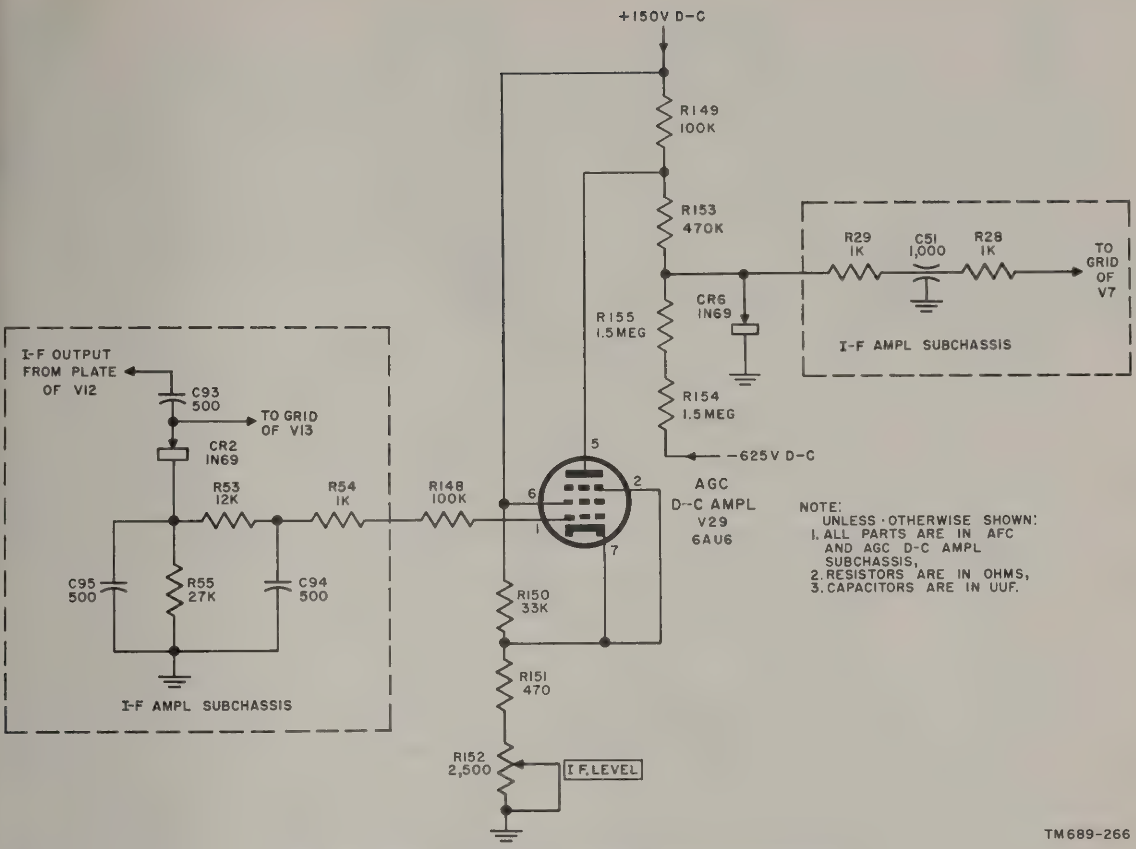

+150V D-C
R149
100K
R153
470K
R29
1K
C51
1,000
R28
1K
TO GRID OF V7
CR6
1N69
R155
1.5MEG
I-F AMPL SUBCHASSIS
I-F OUTPUT FROM PLATE OF V12
C93
500
TO GRID OF V13
CR2
1N69
R154
1.5MEG
-625V D-C
5
R53
12K
R54
1K
R148
100K
6
2
AGC D-C AMPL V29 6AU6
1
7
NOTE:
UNLESS OTHERWISE SHOWN:
1. ALL PARTS ARE IN AFC AND AGC D-C AMPL SUBCHASSIS,
2. RESISTORS ARE IN OHMS,
3. CAPACITORS ARE IN UUF.
C95
500
R55
27K
C94
500
R150
33K
R151
470
I-F AMPL SUBCHASSIS
R152
2,500
I.F. LEVEL
TM689-266

Figure 234. Agc circuit, simplified schematic diagram.

pi-section coupling network; this network couples the voltage developed in the plate circuit of the first limiter through C100 to the grid of second limiter V14, a 5654/6AK5W pentode. The three legs, mutually resonated, form the network which is equivalent in performance and pass band to a conventional double-tuned if. transformer.

g. Second Limiter V14 (fig. 235).

(1) Tube V14 delivers an essentially constant-level output with a varying level input. When an input signal from V13 reaches the grid circuit of V14, the signal charges C101 in proportion to the signal amplitude. The discharge path for C101 must be through R60. Because of the values of these two components, the circuit has a relatively long time constant, effectively establishing a bias level that sets the operating point of the tube in accordance with the input signal level. If the input signal level increases, a larger bias voltage is built up across C101. This reduces the gain, and the output level is maintained fairly constant. Conversely, if the signal level decreases, the bias voltage decreases and the tube gain is raised. Test point E2 is placed in the circuit so the band-pass waveform can be displayed on a test scope for if. alinement purposes. It can also be used to check the bias developed. This bias level is a measure of the limiting action of V13. The test point is connected to the circuit through decoupling circuit R61 and C102.

(2) The tuned circuit in the plate of V14 is comprised of L38 and the plate-cathode capacitance of V14. This cir-

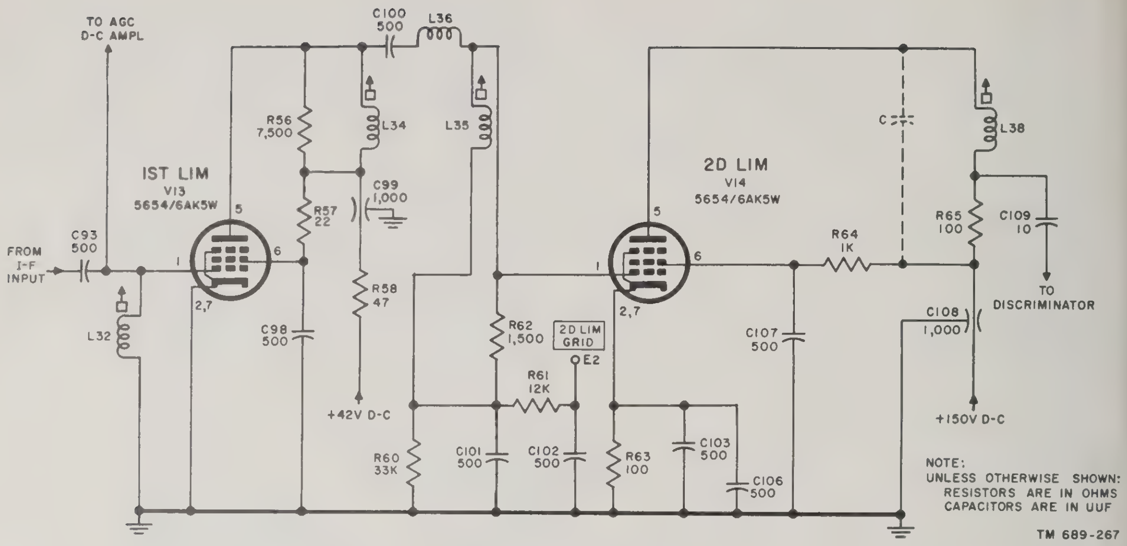

TO AGC
D-C AMPL
C100
500
L36
FROM
I-F
INPUT
C93
500
L32
IST LIM
V13
5654/6AK5W
5
6
1
2,7
R56
7,500
L34
L35
R57
22
C99
1,000
C98
500
R58
47
+42V D-C
R60
33K
C101
500
R62
1,500
2D LIM
GRID
E2
R61
12K
C102
500
R63
100
C103
500
C106
500
2D LIM
V14
5654/6AK5W
5
6
1
2,7
C107
500
R64
1K
C
L38
R65
100
C109
10
TO
DISCRIMINATOR
C108
1,000
+150V D-C
NOTE:
UNLESS OTHERWISE SHOWN:
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UUF
TM 689-267

Figure 235. First and second limiters V13 and V14, simplified schematic diagram.

cuit is resonant at 120 mc. The if. voltage developed across R65 in series with L38 is applied to the discriminator. Capacitors C102 to C108 in this stage are bypass capacitors, while R63 is the cathode-biasing resistor and R64 is the screen-dropping resistor. Resistor R62, shunting L35, provides proper Q for the grid circuit.

h. Discriminator, V15 (fig. 236).

(1) The if. voltage developed across R65 in the plate circuit of the second limiter is applied through coupling capacitor C109 to two series-resonant circuits in discriminator stage V15, a 6AL5W dual diode. One circuit, which consists of L40 in series with the plate-load capacitance of one-half of the dual diode (C1, fig. 236), is resonant at 141 mc. The other circuit, consisting of L39 in series with the plate-cathode capacitance of the other half of the dual diode (C2, fig. 236), is resonant at 108 mc. Two 820-ohm resistors, R68 and R66, are the load resistors for the series-resonant circuits, and also form the grid-load impedance of video preamplifier V16A.

(2) The discriminator feeds its video output to video preamplifier V16 and also feeds the dc component of its output through R70 to METER B, which indicates on off-frequency operation.

i. Video Preamplifier V16 (fig. 237).

(1) The ac output of the discriminator obtained across load resistors R68 and R66 contains the video signal plus the order-wire carrier. This signal is direct-coupled to the grid of V16A (one-half of a 2C51 twin triode), which amplifies it and passes it through cathode follower V16B. Resistor R72 and inductor L42 in the plate circuit of V16A comprise a shunt-peaking circuit, which provides the desired high-frequency response characteristic. Resistor R71 is the cathode-biasing resistor of V16A.

(2) The video voltage developed in the plate circuit of V16A is coupled to the grid of V16V, a cathode follower, through capacitor C116. Resistor R76 is the grid resistor and R74 is the cathode-biasing resistor. The video voltage developed across VIDEO LEVEL control R75, which can be varied to provide the desired output level, is fed to VIDEO OUTPUT jack

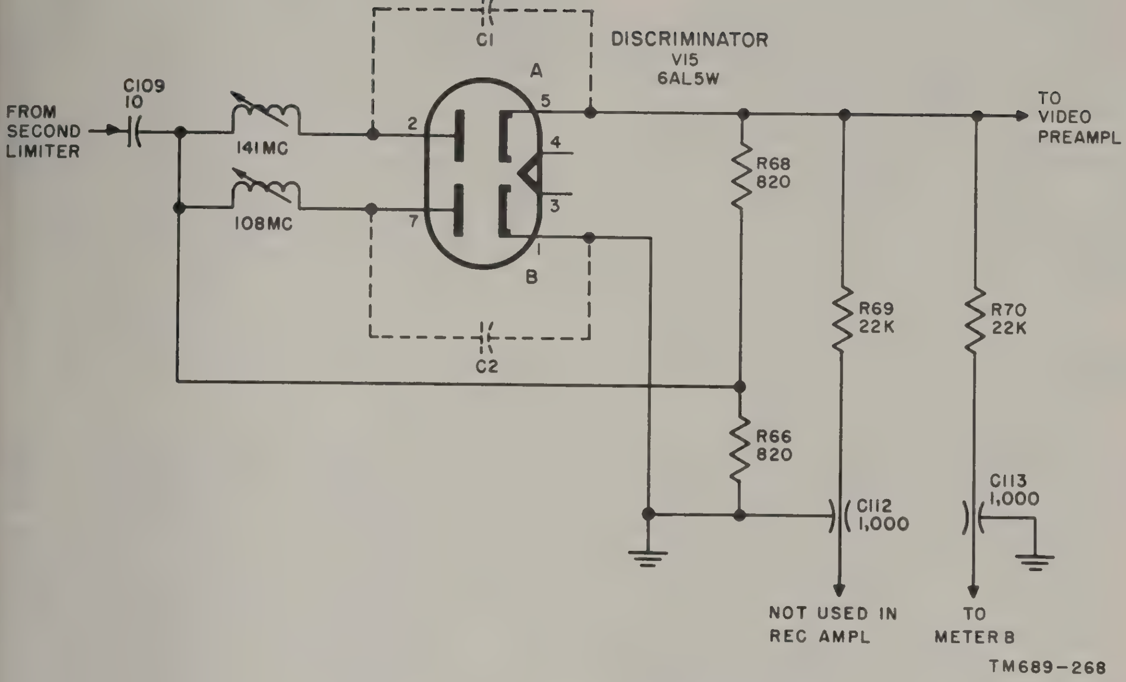

DISCRIMINATOR
V15
6AL5W
FROM
SECOND
LIMITER
C109
10
C1
A
5
2
4
3
7
1
B
141MC
108MC
C2
TO
VIDEO
PREAMPL
R68
820
R69
22K
R70
22K
R66
820
C112
1,000
C113
1,000
NOT USED IN
REC AMPL
TO
METER B
TM689-268

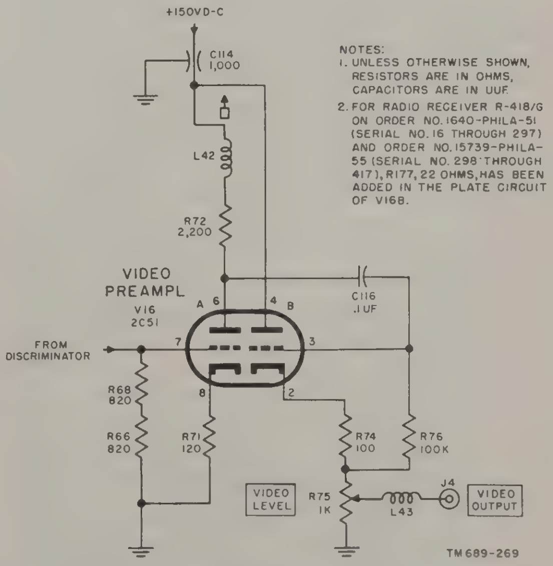
Figure 236. If. discriminator, simplified schematic diagram.

J4 through coil L43, which serves as an if. signal choke. From this point, the video voltage is fed to the video amplifier subchassis.

Note. For Radio Receiver R–418/G on Order No. 1640–Phila–51 (serial No. 16–297) and Order No. 15739–Phila–55 (serial No. 298–417), resistor R177, 22 ohms, has been added in the plate circuit of V16B. This resistor was added to eliminate the tendency for parasitic oscillations in the prevideo amplifier.

181. Video Amplifier

a. General (fig. 238). The combined video and order-wire signal obtained at the output of the video preamplifier (V16) in the if. amplifier subchassis is fed to the video amplifier subchassis. Here the signal is amplified by a 3-stage feedback amplifier consisting of cascaded video amplifiers V17 and V18, and cathode followers V19 and V20, connected in parallel. The overall gain of the amplifier is 0.4, with a frequency response about 1 db down at 7.5 mc. This is as measured at J7 (AT1–VIDEO OUTPUT MONITOR) across 50 ohms.


+150VD-C
C114
1,000
L42
R72
2,200
VIDEO
PREAMPL
V16
2C51
A
6
4
B
7
3
8
2
C116
.1 UF
FROM
DISCRIMINATOR
R68
820
R66
820
R71
120
R74
100
R76
100K
VIDEO
LEVEL
R75
1K
L43
J4
VIDEO
OUTPUT
TM689-269

NOTES:
1. UNLESS OTHERWISE SHOWN, RESISTORS ARE IN OHMS, CAPACITORS ARE IN UUF.
2. FOR RADIO RECEIVER R-418/G ON ORDER NO. 1640-PHILA-51 (SERIAL NO. 16 THROUGH 297) AND ORDER NO. 15739-PHILA-55 (SERIAL NO. 298 THROUGH 417), R177, 22 OHMS, HAS BEEN ADDED IN THE PLATE CIRCUIT OF V16B.

Figure 237. Video preamplifier V16, simplified schematic diagram.

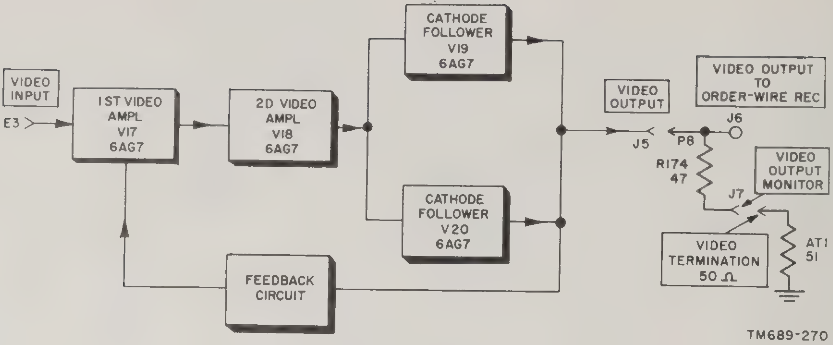


Figure 238. Video amplifier, block diagram.

b. Circuit Description (fig. 397).

(1) *First video amplifier, V17.* The combined video and 6-mc order-wire signal is applied through C117 to the grid of 1st video amplifier V17, a 6AG7 pentode. The signal is amplified by this stage and appears across plate-load resistor R79. Resistors R77 and R78 are parasitic suppressors. The cathode circuit of this stage consists of resistors R89, R92, R94, R95, and R96. These resistors also are used in the cathode circuits of V19 and V20 and form the feedback circuit described in (4) below. The grid bias of V17 is derived across cathode resistors R89 and R92 through grid resistor R84.

(2) *Second video amplifier, V18.* The signal developed across plate resistor R79 is applied through capacitor C118 to the grid of V18, a 6AG7 pentode. The amplified signal appears across plate-load resistor R83 and is coupled to V19 and V20 through C119. Screen-grid voltage is obtained from the +150-volt supply through parasitic suppressor R81. Resistor R80 is the grid resistor, and R82 is the cathode-biasing resistor.

(3) *Cathode follower, V19 and V20.* Tubes V19 and V20, both 6AG7 pentodes, are connected in parallel as a cathode-follower stage, matching the 50-ohm output cable impedance plus terminating impedances. The output voltage is developed across cathode resistors R89, R92, R94, R95, and R96 in series, and coupled to the video output cable through capacitors C120 and C121. Resistors R88 and R93 in the plate circuits and R86 and R91 in the grid circuits are parasitic suppressors. Grid bias is obtained across cathode resistor R89 through grid resistor R85. Resistors R87 and R90 are screen-voltage dropping resistors. Capacitor C122 is a video bypass capacitor.

(4) *Feedback circuit.* A common cathode circuit is used for V17, V19, and V20. Consequently, the output voltage developed across this cathode circuit by V19 and V20 also is applied to the cathode of first video amplifier V17. Because the cathode follower is preceded by a 2-stage amplifier, this feedback voltage is in phase with the signal voltage applied to the grid of V17. Because the feedback moves *with* the grid voltage, it is *degenerative* with respect to the input signal in the sense that it reduces the tube gain by reducing the grid-cathode signal voltage.

182. Afc and Agc Dc Amplifier Subchassis (fig. 398).

a. The afc and agc amplifier subchassis is a small unit that contains two independent amplifier circuits together with their associated controls. Each of these amplifiers is used in conjunction with other portions of the equipment.

b. Afc dc amplifier V28 is a 6AU6 pentode. It corrects the frequency of the klystron local oscillator. It also has facilities for turning the afc function on and off and for controlling and adjusting the reflector, beam, and control-grid voltages for the klystron. Complete details are given in paragraph 178*c*(2).

c. Agc dc amplifier V29 is a 6AU6 pentode. This circuit acts as an automatic gain-adjusting device for the if. amplifier, so that the output of the if. amplifier will be maintained at a constant level. IF. LEVEL potentiometer (par. 180*e*) controls the sensitivity of the agc circuit.

183. Meter Panel

a. General.

(1) All metering circuits in the radio receiver, primary POWER circuit breaker CB1, and RECEIVER ON lamp I 1 are located on the meter panel subchassis. Left hand METER A, M1, meters the circuits indicated and controlled by switch S2. Right hand METER B, M2, meters the circuits indicated and controlled by switch S3. Details of the circuitry at the originating point of each of the metered circuits are given in the description of that circuit.

(2) Generally, voltage measurement is made in the meter circuit by connecting a suitable voltage-dividing meter-multiplier resistor network to the point at which the voltage is measured. Current measurements are made by inserting a small series resistor in the circuit being metered and applying the voltage developed across this resistor to the meter.

(3) Pertinent information for each meter is tabulated in *b* and *c* below. Each chart includes seven columns that contain the following information:

(*a*) *S2* (*or S3*) *pos* column indicates the position of the meter switch.

(*b*) *Pos name* column indicates the front panel marking corresponding to the switch position indicated in the *S2* (*or S3*) *pos* column.

(*c*) *Circuit monitored* column indicates the stage being monitored, and the subassembly on which it is located is listed in the parentheses.

(*d*) *Normal range* column indicates the meter reading range that should be obtained when equipment is operating properly.

(*e*) *TB to meter panel* column indicates the number and terminal board number which feed voltage to the meter panel.

(*f*) *Resistors on meter panel* column indicates the meter resistors that are located on the meter panel.

(*g*) *Resistors on subassembly* column indicates the meter resistors on the subassembly of the stage being monitored.

b. METER A, M1. The chart given below contains pertinent circuit information for METER A, M1.

S2 Pos	Pos name	Circuit monitored	Normal range	TB to meter panel	Resistors on meter panel	Resistors on subassembly
1	AFC 2ND MULT GRID	V23 (afc)	75–140	2, TB7	R158	R107
2	AFC MIXER	CR3 (afc)	30–130	4, TB7	R159	R117
3 and 4	AFC CORRECTION+ and AFC CORRECTION−.	CR4 and CR5 (afc)	0 ±5 (average of two readings).	1 and 2, TB8 and 6 and 7, TB7.	R160	
5	IF. LEVEL	V12 output (if.)	10–30 (no signal)	13, TB8	R164	R126
7	REFL V	V28 (afc and agc dc amplifier).	60–140	11, TB8	R162, R163.	R143
8	BEAM CUR.	Measure V21 beam current.	85–110	10 and 12, TB8.	R156	
9	BEAM V	Measures −675-volt output obtained from power supply.	90–100	10, TB8	R157	

c. METER B, M2. The chart given below contains pertinent circuit information for METER B, M2.

S2 Pos	Pos name	Circuit monitored	Normal range	TB to meter panel	Resistors on meter panel	Resistors on subassembly
1	AFC 1ST MULT GRID	V22 (afc)	30–90	1, TB7		R100
2	AFC 3RD MULT GRID	V24 (afc)	50–80	3, TB7	R166	R111
3	AFC IF. LEVEL	V27 (afc)	20–100	5, TB7	R168	R126
4	IF. MIXER	Z2 (preselector mixer)	60–80	3, TB6	R168	R1
5	IF. DISCR FREQ HIGH.	V15 (if.)	0 ±10	6, TB4	R169	R69
6	IF. DISCR FREQ LOW.	V15 (if.)	0 ±10	6, TB4	R169	R69
7	+150V	+150-volt supply in receiver power supply.	95–110	5, TB5 to 3, TB4 to 12, TB2.	R170	
8	+250V	+250-volt supply in receiver power supply.	95–110	6, TB5 to 13, TB12	R171	

184. Order-Wire Receiver

a. General. The video and 6-mc signal obtained at the output of the radio receiver is fed to the order-wire receiver. Here the video and 6-mc subcarrier signals are separated. The video signal is fed directly out of the order-wire receiver through the VIDEO OUTPUT jack. The subcarrier signal is amplified and detected in the order-wire receiver circuits. The resultant audio signal is amplified further, then fed to the local or remote handset and to the order-wire transmitter (at a repeater station). Incoming signals from the handset are received and fed to the order-wire transmitter. The order-wire receiver also performs the following functions:

(1) *Alarm and ring.* In the absence of a main-channel carrier signal or, if the radio link signal-to-noise ratio is very poor, the order-wire receiver initiates an alarm signal at the point of failure. This alarm signal is maintained as long as the failure exists. Also, a single 2-second buzz is transmitted to all repeaters and terminals, and ringing facilities for normal order-wire party line communications are provided.

(2) *Switchover.* Facilities are provided for transferring operation to a standby receiver if the radio receiver or order-wire receiver should fail.

(3) *Diversity.* The order-wire receiver contains sensing and control circuits for diversity operation of two radio receivers when diversity is installed at the station. The signal-to-noise ratio is monitored continuously in the two receivers. The video of the receiver with the better signal-to-noise ratio is selected as the video output of the receiver at the location.

b. Block Diagram Description (fig. 239).

(1) *Subcarrier amplifier.*

(*a*) The incoming composite video signal, which consists of a 6-mc subcarrier signal superimposed on the multiplexed main-channel video pulse train, enters the order-wire receiver at connector J1 and is fed to the 6-mc trap. This trap has a high series impedance and a low shunt impedance to 6-mc signals, so that the 6-mc energy is diverted through the shunt path and fed to the input of V1. The 6-mc trap presents a high shunt impedance and low series impedance to signals below 6 mc; therefore, the main-channel video intelligence travels through the series path, and the trap effectively separates the two signals. The video signal is fed to diversity control relay K1, which controls it in diversity operation. In normal operation, however, this connection is bypassed by a jumper, and the video information is fed directly from the output of the 6-mc filter to the low pass filter. This filter passes frequencies up to about 5 mc but attenuates all frequencies above that; this filters out any remaining 6-mc signal from the video channel, the output of which appears at J2 and is connected to external equipment.

(*b*) The 6-mc signal is amplified by 1st and 2d carrier amplifiers V1 and V2 and sent to the limiters. A portion of the negative voltage developed at the grid of the 1st limiter V3 is fed back to the grids of V1 and V2 as an agc voltage. The signal is further amplified and limited by 1st and 2d limiters V3 and V4 and fed to discriminator V5, in which it is demodulated.

(2) *Audio and signaling circuits.*

(*a*) The audio output of the discriminator is fed to both through channel amplifier V6B and local channel amplifier V6A. They are fed from the AUDIO LEVEL potentiometer. The through channel section supplies an amplified audio signal to the order-wire transmitter for retransmission, and the local channel section provides audio signals for the local or remote handsets. A portion of

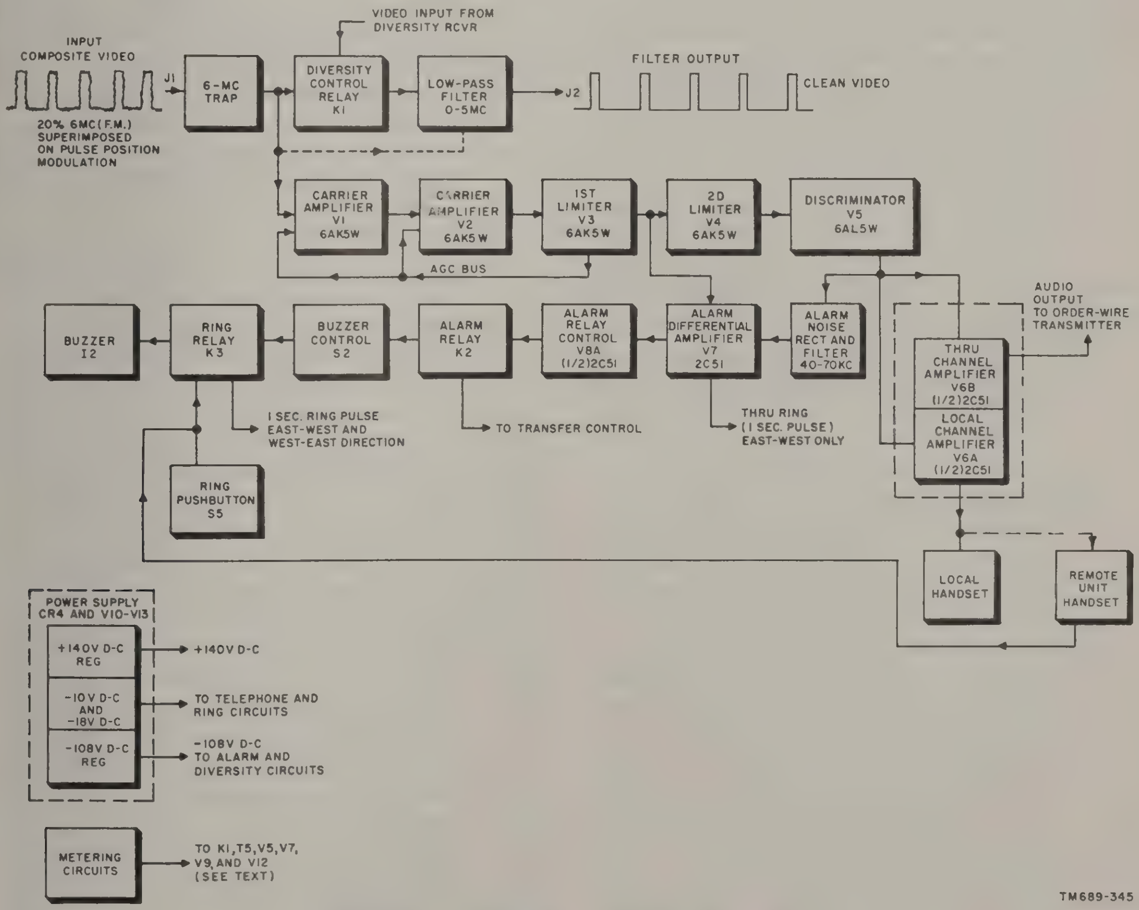

VIDEO INPUT FROM DIVERSITY RCVR
INPUT COMPOSITE VIDEO
J1
6-MC TRAP
DIVERSITY CONTROL RELAY K1
LOW-PASS FILTER 0-5MC
J2
FILTER OUTPUT
CLEAN VIDEO
20% 6MC (F.M.) SUPERIMPOSED ON PULSE POSITION MODULATION
CARRIER AMPLIFIER V1 6AK5W
CARRIER AMPLIFIER V2 6AK5W
1ST LIMITER V3 6AK5W
2D LIMITER V4 6AK5W
DISCRIMINATOR V5 6AL5W
AGC BUS
BUZZER I2
RING RELAY K3
BUZZER CONTROL S2
ALARM RELAY K2
ALARM RELAY CONTROL V8A (1/2)2C51
ALARM DIFFERENTIAL AMPLIFIER V7 2C51
ALARM NOISE RECT AND FILTER 40-70KC
AUDIO OUTPUT TO ORDER-WIRE TRANSMITTER
THRU CHANNEL AMPLIFIER V6B (1/2)2C51
LOCAL CHANNEL AMPLIFIER V6A (1/2)2C51
1 SEC. RING PULSE EAST-WEST AND WEST-EAST DIRECTION
TO TRANSFER CONTROL
THRU RING (1 SEC. PULSE) EAST-WEST ONLY
RING PUSHBUTTON S5
LOCAL HANDSET
REMOTE UNIT HANDSET
POWER SUPPLY CR4 AND V10-V13
+140V D-C REG
+140V D-C
-10V D-C AND -18V D-C
TO TELEPHONE AND RING CIRCUITS
-108V D-C REG
-108V D-C TO ALARM AND DIVERSITY CIRCUITS
METERING CIRCUITS
TO K1, T5, V5, V7, V9, AND V12 (SEE TEXT)
TM689-345

Figure 239. Order-Wire Receiver R–543/TRC–29, order-wire circuits, block diagram.

the outgoing audio from the handset transmitter is fed to the inputs of the audio amplifiers where it is mixed with the existing audio to provide for the handset receiver while the main portion of the outgoing audio from the handset transmitter is fed to the order-wire transmitter. The remote handset is supplied so that the order-wire communication may be carried on at distances of up to 200 feet from the equipment rack in the same manner as is done at the rack with the local handset. In addition, the remote handset contains ringing and signaling facilities.

(*b*) Outgoing ringing signals are initiated by operating RING push button S5 or by the pushbutton on the remote handset unit. Pressing either of these pushbuttons causes ring relay K3 to operate, which causes a ring pulse to actuate the bell in the remote handset and buzzer I 2 in the order-wire receiver. In addition, operation of the ring relay interrupts the subcarrier signal generated in the order-wire transmitters in the station. This interruption of the subcarrier signal is detected by the alarm circuits at the succeeding stations; the alarm circuits then cause the bell and buzzer to ring.

(3) *Alarm circuits.* The dc signal developed at the grid of the second limiter, which is proportional to the 6-mc carrier level, is fed to one-half of alarm differential amplifier V7. The receiver noise spectrum is taken from the discriminator output and passed through a 40- to 70-kc alarm noise filter, which applies a dc signal proportionate to noise level to the other half of the alarm differential amplifier. The circuit of V7 is arranged so that these signals balance the amplifier. Under normal conditions, V7 supplies a positive voltage to grid of alarm relay control V8A, maintaining it in a conducting condition. Since alarm relay K2 is in the V8A plate circuit, the relay is normally operated. If the 6-mc carrier disappears, because of failure of a radio or order-wire transmitter or receiver, or if the signal-to-noise ratio in the main channel that maintains the balance of V7 becomes lower than 24 db, the voltage that V7 supplies to V8A becomes negative. When this happens, V8A is cut off and K2 releases, which closes circuits that initiate a 2-second alarm signal down the microwave system. However, the buzzer at the unit initiating the alarm sounds continuously until either the condition is corrected or BUZZER CONTROL switch S2 is thrown to the MONITOR position. The buzzer is silenced when S2 is in MONITOR position, but the circuits are monitored; when normal conditions are resumed, the buzzer sounds again. This indicates the fact to the operator, who returns the switch to NORMAL position, silencing the buzzer.

(4) *Power supplies.* Two self-contained power supplies are included in the order-wire receiver. One supply contains a bridge-type selenium rectifier, which furnishes —18 volts dc for the signaling circuits and —10 volts dc for the telephone talking circuits. The other supply (V10–V13) is an electronically regulated supply, which includes two rectifiers, a series-regulator tube, a dc control amplifier, and a shunt regulator and voltage reference tube. One rectifier feeds the series-regulator tube, whose output is 140 volts dc. The output voltage is kept constant by varying the series resistance of the regulator tube. This is controlled by the dc control amplifier, the grid voltage of which is obtained by sampling the output voltage of the supply. The other rectifier supplies a voltage to the cathode of the gas-tube shunt regulator. The voltage across this tube is held at —108 volts dc. When a large current flows through the tube, the gas is highly

ionized, and the internal impedance of the tube is low; conversely, when a small current flows, the gas is less ionized, and the impedance of the tube is high. The product of the current through the tube and the internal impedance, which represents the voltage drop across it, remains practically constant over the operating range. The —108 volts is used as a reference voltage for the 140-volt supply, as well as for biasing purposes in the alarm and diversity circuits. The 140 volts dc is used for plate and screen supply voltages for all the order-wire receiver tubes which require such voltages.

(5) *Metering circuits.* Meter M1 and meter selector switch S1 monitor voltages in the order-wire receiver. The following voltages can be metered by appropriate settings of S1: order-wire carrier level, average discriminator output level, audio level, diversity control signal level, diversity operating indication, and the output of the 140-volt power supply.

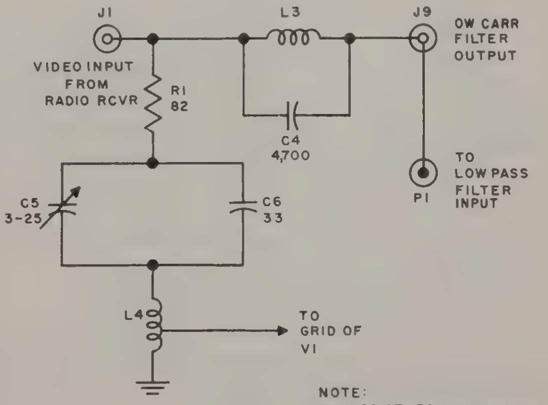
185. Subcarrier Amplifier

a. Composite Video Filter (fig. 240).

(1) *General.* The composite video filter consists of two sections: the 6-mc trap (order-wire subcarrier filter), which extracts the 6-mc subcarrier signal for use by the order-wire receiver; and the low pass filter, which cuts off the video band above about 4.5 mc to improve the main-channel video signal-to-noise ratio of the radio receiver and to remove 6-mc components from the video signal. When diversity is used, the two sections are separated by the contacts of diversity control relay K1. During normal operation, however, a jumper between jack J9 and plug P1 connects the two sections.

(2) *Six-mc trap.* The composite video signal from the radio receiver is fed to the order-wire chassis through jack J1. The incoming signal can follow one of two paths. One path, comprised of parallel-tuned L3 and C4, presents a relatively high impedance to the 6-mc subcarrier signal but a much lower impedance to the video signal with frequency components from 0 to 4.5 mc. The second path, consisting of R1, with L4 series tuned by the combined capacity of C5 and C6, presents a relatively high impedance to the video signal, but a low impedance to the 6-mc signal, because C5 is tuned to obtain series resonance at 6 mc. The overall result is that the video signal is passed through L3 and C4 to J9, while the 6-mc signal is fed to the grid of V1 through a tap on L4.

(3) *Low pass filter* (fig. 241). The video signal obtained from J9 is fed to the low pass filter. This filter employs and *m-derived.* T-configuration consisting of R80, L2, C3, C2, L1, C1, and a 50-ohm terminating resistor at the output of the video output cable. This latter resistor is electrically a part of the filter, although it is physically located in another equipment. The low pass filter passes all frequencies from 0 to 4.5 mc with little attenuation, as shown in figure 241. However, above 5.5 mc, the signal attenuation increases sharply with frequency, so that at 6.0 mc the attenuation is 20 db. Consequently, little 6-mc signal exists at the output of the low pass filter.



NOTE:
UNLESS OTHERWISE SHOWN:
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UUF

TM 689-346

Figure 240. Video composite filter, schematic diagram.

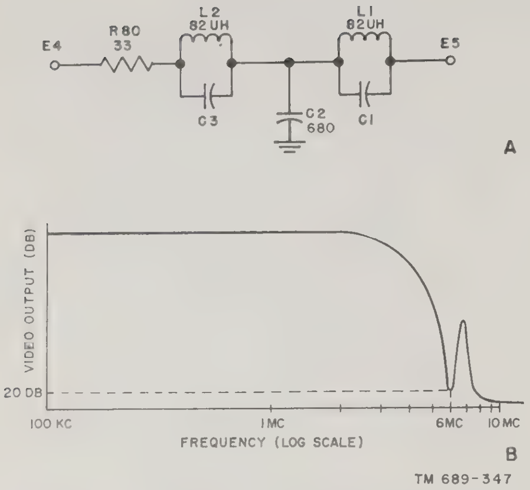

E4
R80
33
L2
82 UH
C3
C2
680
L1
82 UH
C1
E5
A
VIDEO OUTPUT (DB)
20 DB
100 KC
1 MC
6MC
10 MC
FREQUENCY (LOG SCALE)
B
TM 689-347

Figure 241. Composite video filter, response curve.

b. Six-mc Carrier Amplifiers V1 and V2 (fig. 242).

(1) The 6-mc signal obtained from tap on L4 in the 6-mc trap is coupled through capacitor C7 to the first 6-mc carrier amplifier, V1 (a 5654/6AK5W pentode). The signal is amplified in this stage for which the primary of double-tuned transformer T1 is the plate load. The secondary of this transformer, which is also tuned to 6 mc, is coupled through capacitor C10 to the grid of V2, the second 6-mc carrier amplifier. The amplified signal from this stage is developed across the primary of T2, another double-tuned 6-mc transformer.

(2) Fixed bias on the cathode of stages V1 and V2 is obtained from the +140-volt supply through voltage-divider networks R5, R3 and R11, R10, respectively. The grids of V1 and V2 are biased by the agc bus through grid resistors R2 and R9. As the 6-mc carrier signal level increases, the agc bias becomes more negative and reduces the gain of stages V1 and V2; this tends to maintain a constant signal at the primary of T2. Resistors R7 and R12 are plate- and screen-voltage dropping resistors, and C9, C12, C8, and C11 are bypass capacitors.

c. First and Second Limiters, V3 and V4 (fig. 243).

(1) The output developed across the secondary of T2 is fed through capacitor C13 to the grid of the first limiter, V3 (a 5654/6AK5W pentode). Limiting occurs in this stage because the grid draws current during the peaks of the positive half-cycles and is driven beyond cutoff during negative half-cycles. The limited signal is developed

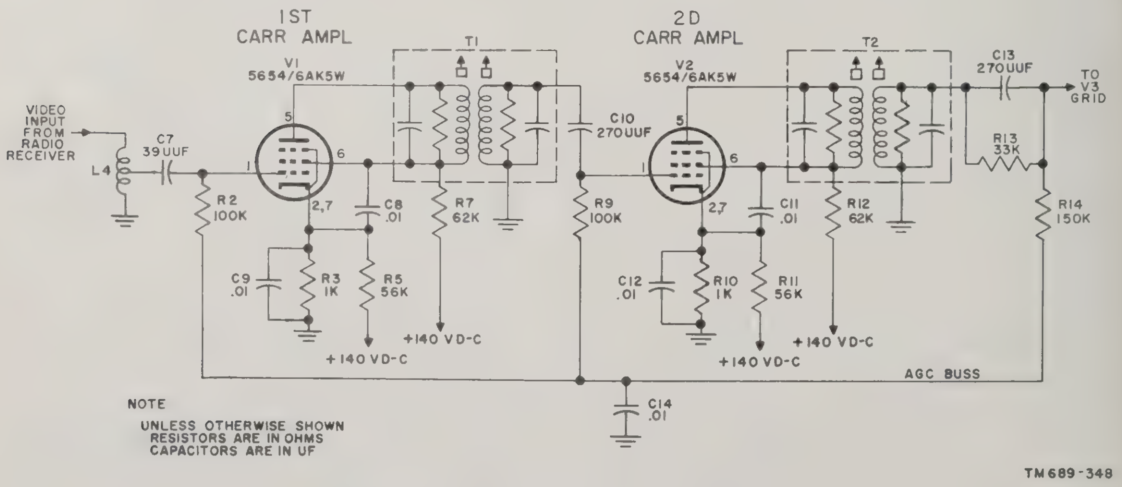

1ST
CARR AMPL
V1
5654/6AK5W
VIDEO INPUT FROM RADIO RECEIVER
L4
C7
39UUF
R2
100K
5
1
6
2,7
C8
.01
C9
.01
R3
1K
R5
56K
+140 VD-C
T1
R7
62K
+140 VD-C
C10
270UUF
R9
100K
2D
CARR AMPL
V2
5654/6AK5W
5
1
6
2,7
C11
.01
C12
.01
R10
1K
R11
56K
+140 VD-C
T2
R12
62K
+140 VD-C
C13
270UUF
TO V3 GRID
R13
33K
R14
150K
AGC BUSS
C14
.01
NOTE
UNLESS OTHERWISE SHOWN
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UF
TM 689-348

Figure 242. Six-mc carrier amplifiers V1 and V2, simplified schematic diagram.

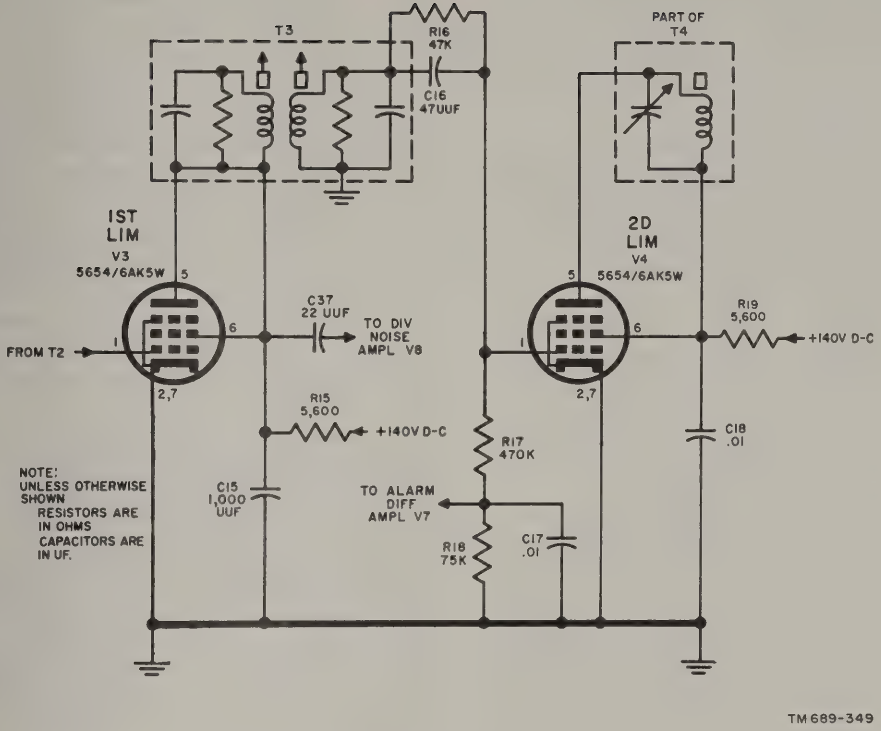

T3
R16
47K
C16
47UUF
PART OF
T4
IST
LIM
V3
5654/6AK5W
5
6
1
2,7
FROM T2
C37
22 UUF
TO DIV
NOISE
AMPL V8
2D
LIM
V4
5654/6AK5W
R19
5,600
+140V D-C
R15
5,600
+140V D-C
R17
470K
C18
.01
NOTE:
UNLESS OTHERWISE
SHOWN
RESISTORS ARE
IN OHMS
CAPACITORS ARE
IN UF.
C15
1,000
UUF
TO ALARM
DIFF
AMPL V7
R18
75K
C17
.01
TM 689-349

Figure 243. First and second limiters V3 and V4, simplified schematic diagram.

across the primary of T3, a double-tuned 6-mc transformer.

(2) During a portion of the positive half-cycle, the grid-to-cathode circuit acts as a rectifier (the grid draws current) and develops a dc voltage across filter network R13 and C13 whose amplitude is proportional to the magnitude of the applied signal (fig. 242). This negative dc voltage, which is isolated by R14 and filtered by C14, is applied to the agc bus. It also provides the grid bias for this stage.

(3) The 6-mc signal applied to the limiter contains an amplitude-modulated envelope caused primarily by noise existing in the radio receiver. This amplitude-modulated component is detected in the screen-grid circuit of V3, and partially filtered by filter network C15 and R15. The signal developed across this network is coupled to the grid of V8B, the diversity-noise amplifier. This signal is proportional to the amount of noise existing in the radio receiver.

(4) The voltage developed in the plate circuit of V3 is transformer-coupled by T3 to the grid of the second limiter V4 (a 5654/6AK5W pentode). Limiting occurs in this stage because the grid draws current during the peaks of the positive half-cycle and is driven beyond cutoff during the negative half-cycle. The grid-to-cathode circuit acts as a rectifier and develops a negative dc voltage across filter R16 and C16. This provides the grid bias for the tube, and a portion of this voltage is tapped off at the junction of R17 and R18 and is fed to the alarm differential amplifier V7 (par. 187*b*). The

magnitude of this voltage is proportional to the signal level of the order-wire receiver. Capacitor C17 filters out any 6-mc component existing at this point, while C18 is a screen bypass capacitor.

d. Discriminator, V5 (fig. 244).

(1) Tube V5 is a 6AL5W twin diode connected in a phase discriminator circuit. The output of second limiter V4 is fed to this circuit through transformer T4. The discriminator demodulates the 6-mc fm carrier and provides an audio signal output when an audio signal is applied to the originating order-wire transmitter.

(2) For a detailed explanation of the action of this discriminator, refer to paragraph 171*c*(2)(*c*).

(3) The overall amplitude-versus-frequency curve of the discriminator is shown on figure 198. This figure shows the output is zero when the carrier frequency is 6 mc, rises linearly to +8.8 volts for a +80-kc deviation, and declines linearly to —8.8 volts for a —80-kc deviation. The output voltage obtained is the audio signal which was used to modulate the originating order-wire transmitter.

(4) The audio voltage developed across C21 is filtered by R24 and C22 (which remove any remaining 6-mc signal) and is applied across potentiometer R26, the AUDIO LEVEL control. A portion of this voltage, its magnitude depending on the setting of R26, is fed to the audio amplifier section of the order-wire receiver. The output voltage is also fed through resistor R25 and switch S1 to meter M1.

186. Audio and Signaling Circuits

a. General. The audio circuits include a through channel audio amplifier, whose output is fed to the following order-wire transmitter in a repeater installation (this circuit is not used at a terminal): a local channel audio amplifier, which feeds the local and remote handsets; and telephone circuits and audio interconnections necessary for conducting a telephone conversation in party line operation. The required signaling circuits are also included.

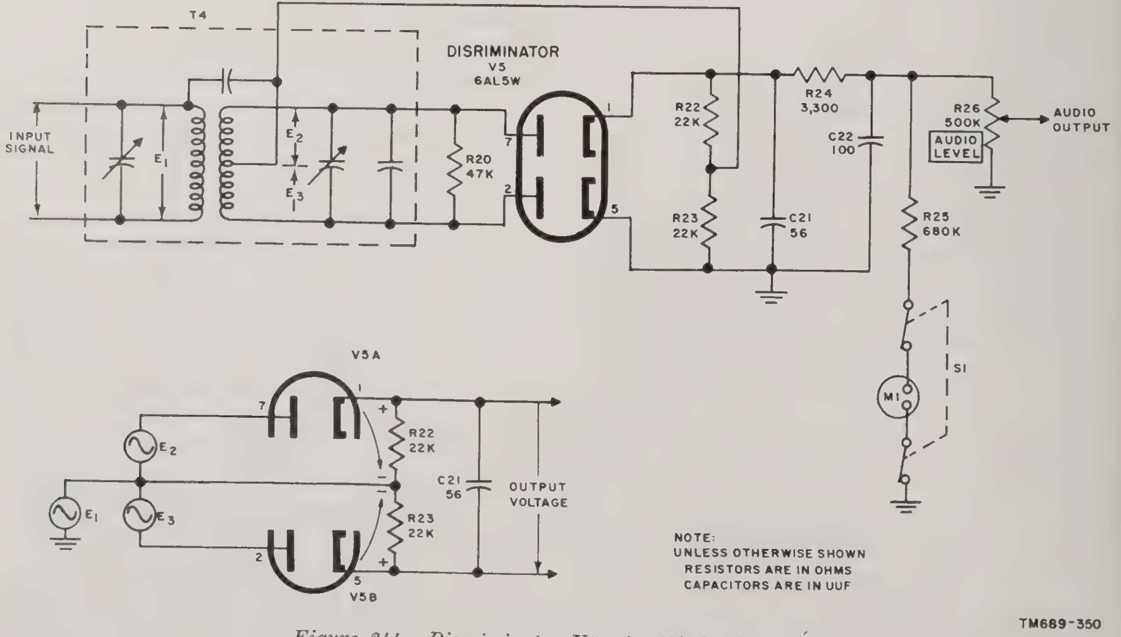

T4
INPUT SIGNAL
E1
E2
E3
DISRIMINATOR
V5
6AL5W
R20 47K
1
2
5
7
R22 22K
R23 22K
R24 3,300
C22 100
C21 56
R26 500K
AUDIO LEVEL
AUDIO OUTPUT
R25 680K
M1
S1
V5A
V5B
OUTPUT VOLTAGE
NOTE:
UNLESS OTHERWISE SHOWN
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UUF
TM689-350

Figure 244. Discriminator V5, simplified schematic diagram.

b. Through Channel Amplifier V6B (fig. 245).

(1) The incoming through audio signal is obtained from the discriminator and the AUDIO LEVEL control and coupled through R27, C23, and voltage divider formed by R28, R29, and R77 to the grid of V6B, one-half of a 2C51 twin triode. The grid of through channel audio amplifier V6B is fed from a junction of R28 and R29. Cathode bias is developed across R30, which is bypassed for audio by C26A. The output is coupled from plate load resistor R35 through C27, C28, C29, and R34 to terminal E of REPEATER INTERCONN connector J7; this modulates the order-wire transmitter.

(2) Low-frequency equalization is inserted by RC network C27, C28, C29, and R34. High-frequency equalization is furnished by R34, R33, and C25 at the output, and R28, R29, and C24 at the input. The sidetone coupling network R31, R36, and C23, used in the local audio amplifier input circuit (fig. 246), also aids the high-frequency equalization.

c. Local Channel Amplifier (fig. 246).

(1) The local channel audio amplifier is used to drive the local and remote telephone receivers. The input circuit for this stage is the same as that used for the through channel audio amplifier, from AUDIO LEVEL control R26 through C23 and across high-frequency equalization network R28, R29, C24, and R77 to the grid of V6A (the other half of the 2C51 twin triode). Cathode bias is developed across R32. The unbypassed cathode resistor causes degeneration and this improves the frequency response of the stage. The plate load of V6A is the primary of telephone impedance-matching transformer T5.

(2) The audio output obtained from the secondary of transformer T5 is coupled through C31 to the following outputs: local handset receiver HS1 (TB2–B) through R37, remote handset receiver REC, and REPEATER INTERCONN connector J7 (terminal K). The repeater interconnection lead connects in parallel the telephone transformer of this order-wire receiver and the other order-wire receiver (for the opposite direction) at the repeater station, so that both operating order-wire receivers in a repeater feed the same handsets. This is done so that a signal entering the repeater station from either direction can be heard in any headset. Resistors R31 and R36 and capacitor C32, in addition to providing high-frequency

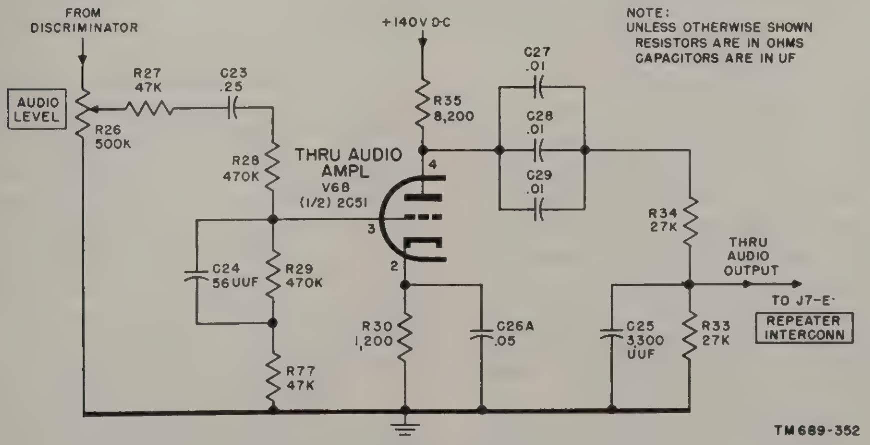

FROM DISCRIMINATOR
+140V D-C
NOTE:
UNLESS OTHERWISE SHOWN
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UF
AUDIO LEVEL
R26 500K
R27 47K
C23 .25
R35 8,200
C27 .01
C28 .01
C29 .01
R28 470K
THRU AUDIO AMPL
V6B (1/2) 2C51
4
3
2
C24 56UUF
R29 470K
R77 47K
R30 1,200
C26A .05
R34 27K
THRU AUDIO OUTPUT
TO J7-E
REPEATER INTERCONN
C25 3,300 UUF
R33 27K
TM 689-352

Figure 245. Through channel audio amplifier V6B, simplified schematic diagram.

equalization, are used to couple a small portion of the speech signal (which originates at the local handset transmitter) through the local audio amplifier to provide a sidetone signal to the handset receiver.

(3) The audio output is also detected by CR1, a germanium crystal diode, and fed through resistor R4 and selector switch S1 to meter M1.

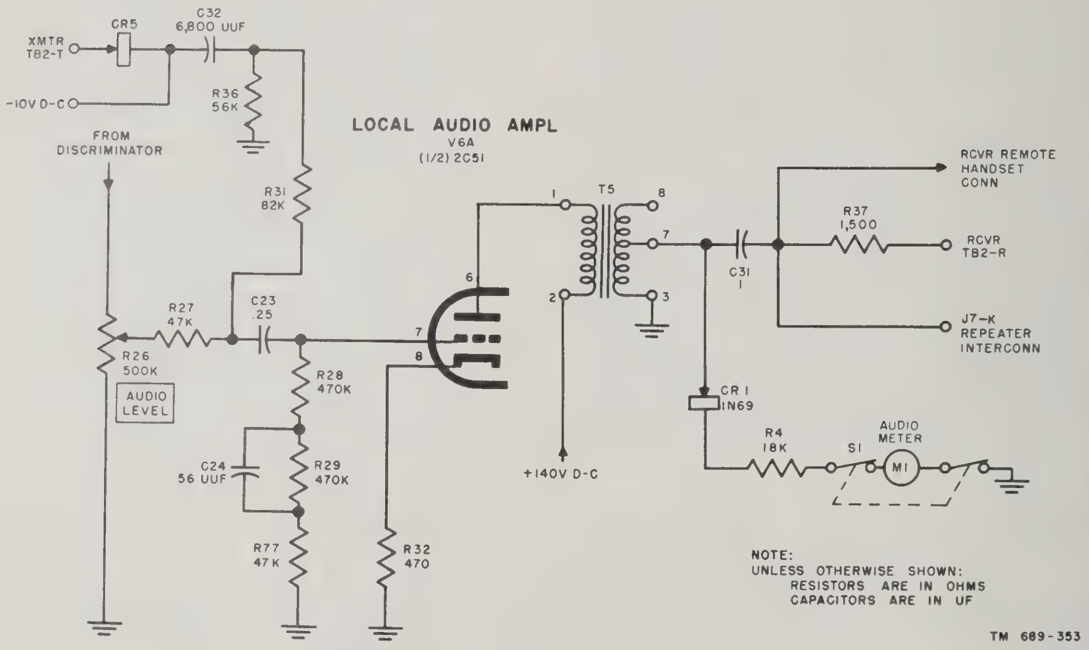

XMTR TB2-T
CR5
C32 6,800 UUF
-10V D-C
R36 56K
FROM DISCRIMINATOR
LOCAL AUDIO AMPL
V6A (1/2) 2C51
R31 82K
R27 47K
C23 .25
R26 500K
AUDIO LEVEL
R28 470K
C24 56 UUF
R29 470K
R77 47K
R32 470
6
7
8
1
2
T5
8
7
3
+140V D-C
C31 1
RCVR REMOTE HANDSET CONN
R37 1,500
RCVR TB2-R
J7-K REPEATER INTERCONN
CR 1 1N69
R4 18K
S1
AUDIO METER
M1
NOTE:
UNLESS OTHERWISE SHOWN:
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UF
TM 689-353

Figure 246. Local channel audio amplifier V6A, simplified schematic diagram.

d. Telephone and Signaling Circuits and Audio Interconnections (fig. 247).

(1) *General.* The telephone handsets and circuits are common to both order-wire receivers in a repeater station so that it is possible to hold a conversation in either direction. The interconnections between the two order-wire receivers, as well as the common telephone circuits, are shown on figure 247. To distinguish between the two order-wire receivers, one receiver is arbitrarily called the east-west receiver, and the other is called the west-east receiver.

(2) *Through signal.*

(*a*) The through channel signal is coupled from the plate of amplifier V6B to terminal E of REPEATER INTERCONN connector J7, and through a jumper built into the REPEATER INTERCONN cable between terminal E and A. From A of J7 it goes to A of J6, the ORDER WIRE INTERCONN connector, the cable from which is connected to the following east-west order-wire transmitter (terminal A of J1). The REPEATER INTERCONN cable is *not* used at a terminal station; therefore, the jumper from E to A on J7 is not present. This prevents a through signal reaching the terminal from going back down the line and reechoing.

(*b*) The local handset receives the incoming signal by local audio amplifier V6A through isolating resistor R37. The remote handset receives the incoming signal through the

REC terminal, which is connected to the junction of C31 and R37. The operator at the west-east order-wire receiver rack may also listen to the message because both telephone transformers T5 are fed in parallel, interconnected through C31, terminals I of J7, and the REPEATER INTERCONN cable.

Figure 247. Audio and local ring interconnections for repeater operation, simplified schematic diagram.
(Contained in separate envelope)

(3) *Local signal.* An operator talking at any of the local or remote handsets is heard at all stations down the line in both directions. The speech is coupled from the telephone transmitter through C39 to terminal D of J6 (ORDER WIRE INTERCONN) and terminal D of J7 (REPEATER INTERCONN), and then to terminals D of J1 on both order-wire transmitters (east-west and west-east) to modulate both local channels. Because capacitor C39 in one order-wire receiver connects to C39 in the other through the REPEATER INTERCONN cable, CR5 is inserted in the circuit to prevent double loading on the telephone transmitter. For sidetone, the speech is fed back through CR5, C32, and R31 to the grid of the local audio amplifier V6A and is heard at the handset receiver, though greatly attenuated.

(4) *Remote handset.*

(*a*) The remote handset can be used at a distance up to 200 feet from the order-wire receiver rack. For this service, the local handset is disconnected from the order-wire receiver and connected to the remote handset unit with two pairs of field wire. An operator away from the rack still has full party line service and may ring down the line. He may also hear a failure alarm (a continuous ringing of the bell) in the remote handset unit.

(*b*) Resistor R1 acts as an isolating resistance for the handset receiver, S2 is the hook switch, and CR1 is a rectifier that prevents bell I 1 from loading the handset receiver by acting as a high impedance when no dc is being applied to the bell. When an operator presses push button S1 on the remote handset (or RING button S5 in the order-wire receiver), —18 volts dc is applied through CR6 and ring relay K3 to ground. Ring relay K3 is pulled in and —18 volts dc is applied through contacts 11 and 2 of K3 to the remote handset REC terminal to ring bell I 1. At the same time, contacts 5 and 12 on K3 close and apply 115 volts ac to operate buzzer I 2. Crystal CR6 polarizes ring relay K3, because the coils of K3 in both the east-west and west-east receivers are tied together at terminals 7 of J7 through the REPEATER INTERCONN cable. The high back resistance of the crystal prevents actuation of K3 in the west-east receiver when voltage is applied at terminal J of J7 from the east-west receiver. With CR6 in the circuit, K3 can be actuated only when it is grounded by either S1 or S5.

(5) *Local ring.*

(*a*) Ringing down the line is accomplished by the interruption of the 6-mc subcarrier signal. This is done by keying off each succeeding order-wire transmitter carrier with a negative pulse. To prevent complete interruption of order-wire service if an operator should keep the ring button pressed, rings are limited to about 1-second duration. Capacitor C48B charges up to —18 volts dc through break contacts 11 and 1 on the K3 ring relay when K3 is released. When K3 is energized, C48B is discharged through contacts 10 and 14 of K3 and R17 in the succeeding order-wire transmitter to ground. The resulting 1-second negative ring pulse goes from terminal 14 of K3 to terminal C of J6 (ORDER WIRE INTERCONN) through the cable to terminal C of

J1 in the east-west order-wire transmitter.

(*b*) The pulse cuts off the 6-mc signal by applying a high negative bias to the suppressor grid of the final carrier amplifier in the order-wire transmitter (par. 171*c*(1)(*d*)), causing a 1-second subcarrier interruption. If the ring relay in the west-east order-wire receiver is energized, the 1-second pulse cuts off the order-wire transmitter operating in the west-east direction. An operator hears his own ring at the order-wire receiver, because 115 volts ac is applied through contacts 5 and 12 of K3 to ac BUZZER I 2. The application of —18 volts dc through contacts 11 and 12 of K3 to the REC terminal enables the operator at the remote handset to hear his own ring.

(6) *Through ring* (fig. 248).

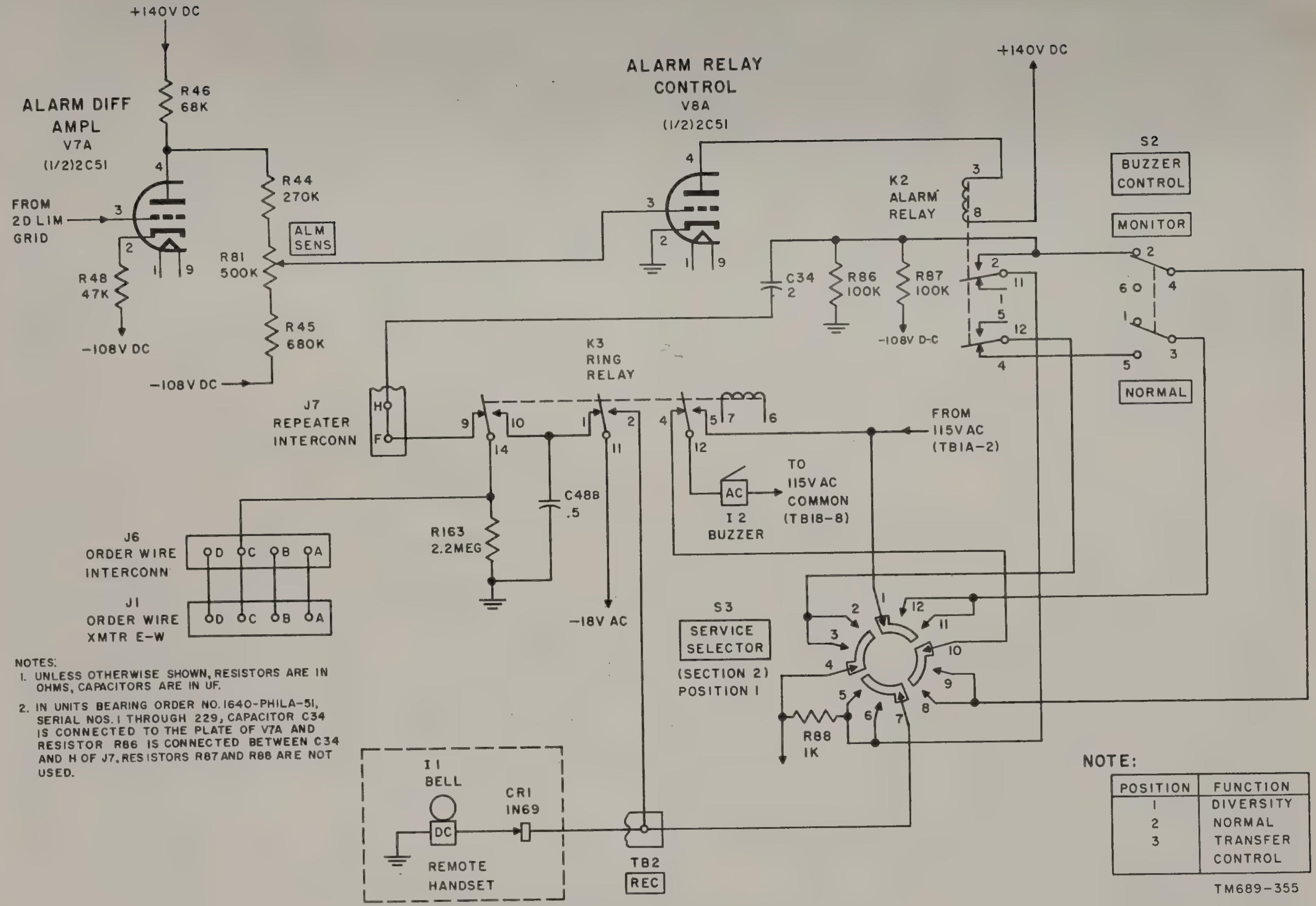
(*a*) A ring that originates at a preceding east-west station must be connected through the order-wire receiver to the order-wire transmitter and transmitted down the line east-west. The order-wire receiver alarm circuit senses the through ring as a 1-second carrier failure. The output of alarm differential amplifier V7 produces a drop in voltage (negative pulse); the voltage passes through R34 and R86 and is coupled from terminal H to terminal F of J7 through a jumper in the REPEATER INTERCONN cable and through break contacts 9 and 14 of K3 to terminal C of J6 (ORDER WIRE INTERCONN). The voltage cuts off the east-west order-wire transmitter for 1 second.

Note. For Order-Wire Receiver R-543/TRC-29 on Order No. 1640-Phila-51 (serial No. 230-297) and Order No. 15739-Phila-55 (serial No. 298-417), the output of alarm differential amplifier V7A produces a drop in voltage (negative pulse); the voltage cuts alarm relay control tube V8A off and deenergizes alarm relay K2. This causes the —18 volts, which is derived from the telephone supply rectifier through contacts 2 and 11 of alarm relay K2, to be removed from the junction of C34, R86, and R87. Instead, —54 volts, which is obtained from the -108-volt bias supply through voltage divider R86 and R87, then appears at the same point. Thus, when relay K2 is deenergized the voltage appearing at C34 drops from —18 to —54 volts and a —36-volt pulse is coupled through C34. The negative pulse passes from terminal H to terminal F of J7 through a jumper in the REPEATER INTERCONN cable and through break contacts 9 and 14 of K3 to terminal C of J6 (ORDER WIRE INTERCONN).

(*b*) The east-west through ring is heard locally at the east-west order-wire receiver only, and at the east-west and west-east remote handsets. The 1-second negative pulse at the plate of V7 is applied to the grid of V8A and cuts it off. Alarm relay K2 releases momentarily, because its coil is the plate load of V8A. The —18 volts dc then is applied to the remote handset bell through contacts 4 and 5 of SERVICE SELECTOR switch S3, break contacts 11 and 1 of K2, contacts 6 and 4 of BUZZER CONTROL switch S2, and contacts 8 and 7 of S3 to the REC terminal of the remote handset and then to the bell. Because the REC terminals in the east-west and west-east order-wire receivers are connected together through the K lead of the repeater cable, both bells ring. One hundred and fifteen volts ac is fed to ac BUZZER I 2, through contacts 1 and 2 of S3, break contacts 12 and 4 of K2, contacts 5 and 3 of S2, contacts 11 and 10 of S3, break contacts 4 and 12 of K3 to ac BUZZER I 2. Therefore, the buzzer (in the east-west order-wire receiver only) sounds at the same time.

187. Alarm Circuits

a. General. When the order-wire receiver fails to detect a 6-mc subcarrier signal, or when the 6-mc signal-to-noise ratio is below 8 to 12 db, an alarm circuit is actuated. The 2-second alarm signals to all stations up and down the microwave system and continuously rings the


+140V DC
R46
68K
ALARM DIFF
AMPL
V7A
(1/2)2C51
FROM
2D LIM
GRID
R48
47K
-108V DC
R44
270K
ALM
SENS
R81
500K
R45
680K
-108V DC
ALARM RELAY
CONTROL
V8A
(1/2)2C51
K2
ALARM
RELAY
+140V DC
C34
2
R86
100K
R87
100K
-108V D-C
S2
BUZZER
CONTROL
MONITOR
NORMAL
K3
RING
RELAY
J7
REPEATER
INTERCONN
H
F
FROM
115V AC
(TB1A-2)
C488
.5
R163
2.2MEG
-18V AC
AC
I2
BUZZER
TO
115V AC
COMMON
(TB18-8)
J6
ORDER WIRE
INTERCONN
J1
ORDER WIRE
XMTR E-W
D
C
B
A
S3
SERVICE
SELECTOR
(SECTION 2)
POSITION 1
R88
1K
I1
BELL
DC
CR1
1N69
REMOTE
HANDSET
TB2
REC
TM689-355

NOTES:

1. UNLESS OTHERWISE SHOWN, RESISTORS ARE IN OHMS, CAPACITORS ARE IN UF.
2. IN UNITS BEARING ORDER NO. 1640-PHILA-51, SERIAL NOS. 1 THROUGH 229, CAPACITOR C34 IS CONNECTED TO THE PLATE OF V7A AND RESISTOR R86 IS CONNECTED BETWEEN C34 AND H OF J7. RESISTORS R87 AND R88 ARE NOT USED.

NOTE:

POSITION	FUNCTION
1	DIVERSITY
2	NORMAL
3	TRANSFER CONTROL

Figure 248. Through ring and alarm signal circuit, simplified schematic diagram.

buzzer at the order-wire receiver where failure was detected. Conditions for an alarm may be caused either by a defective radio receiver or by an order-wire receiver at the station initiating the alarm, or by a defective order-wire transmitter or by a radio transmitter at the station, which is transmitting to the station initiating the alarm.

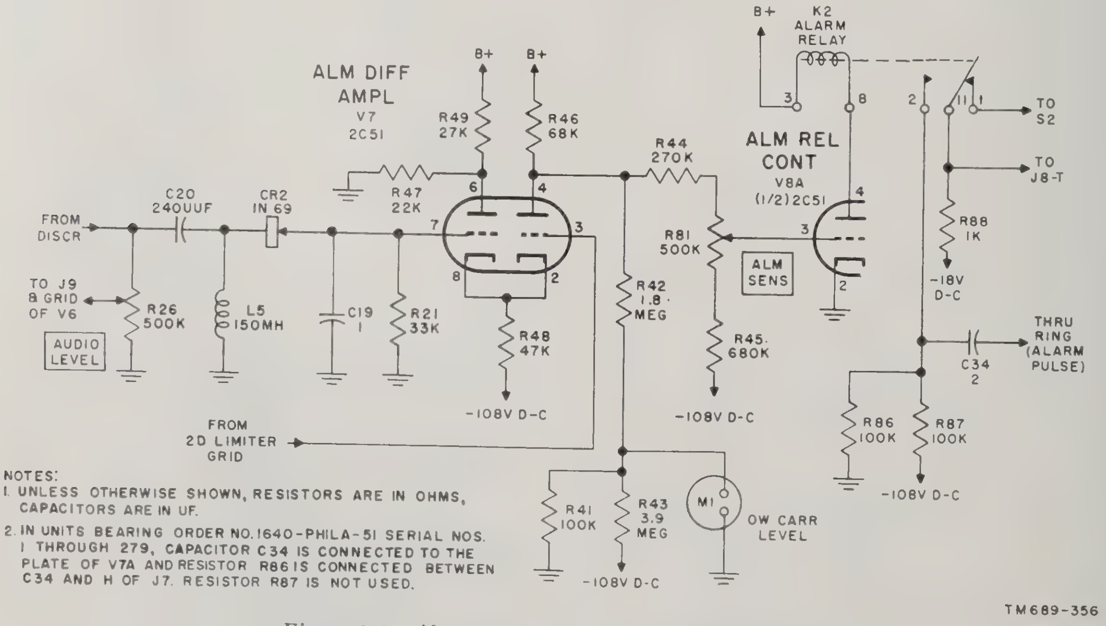
b. Alarm Differential Amplifier V7 (fig. 249).

(1) The alarm differential amplifier consists of 2C51 twin triode V7. A portion of the negative voltage developed in the grid-to-cathode circuit of second limiter V4 is fed to the grid of V7A. A portion of the discriminator output developed across AUDIO LEVEL potentiometer R26 is fed to the grid of V7B through an alarm noise filter network, C20, L5, CR2, C19, and R21, which acts as a narrow-band filter and passes signals with frequency components from 40 to 70 kc. This provides a dc signal proportional to audio output noise. These voltages are compared in V7.

(2) The second limiter grid voltage is a negative signal, the amplitude of which is a function of the magnitude of the 6-mc carrier signal present at the grid of V4. With a normal signal, a low noise component level exists at the input of the alarm noise filter. However, as the signal-to-noise ratio in the main channel decreases below the threshold value of 26 to 16 db, noise components are received at the output of the discriminator and develop a negative voltage across R21 and C19.

(3) Stage V7A is connected as a conventional amplifier. Stage V7B is connected as a cathode follower with its plate circuit connected to an essentially constant voltage provided by the voltage-divider network of R49 and R47 connected to +140 volts. Cathode resistor R48 is common to both stages.

(4) When power is first turned on in this equipment, no output is obtained from either the second limiter grid or noise circuits, and both tubes conduct. Consider the effect of the application of



ALM DIFF AMPL
V7
2C51
B+
B+
R49 27K
R46 68K
R47 22K
C20 240UUF
CR2 IN 69
FROM DISCR
TO J9 & GRID OF V6
R26 500K
AUDIO LEVEL
L5 150MH
C19 1
R21 33K
R48 47K
-108V D-C
FROM 2D LIMITER GRID
6
4
7
3
8
2
R44 270K
R42 1.8 MEG
R81 500K
ALM SENS
R45 680K
-108V D-C
R41 100K
R43 3.9 MEG
-108V D-C
M1
OW CARR LEVEL
B+
K2 ALARM RELAY
3
8
ALM REL CONT
V8A (1/2)2C51
4
3
2
2
11
1
TO S2
TO J8-T
R88 1K
-18V D-C
THRU RING (ALARM PULSE)
C34 2
R86 100K
R87 100K
-108V D-C
NOTES:
1. UNLESS OTHERWISE SHOWN, RESISTORS ARE IN OHMS, CAPACITORS ARE IN UF.
2. IN UNITS BEARING ORDER NO.1640-PHILA-51 SERIAL NOS. 1 THROUGH 279, CAPACITOR C34 IS CONNECTED TO THE PLATE OF V7A AND RESISTOR R86 IS CONNECTED BETWEEN C34 AND H OF J7. RESISTOR R87 IS NOT USED.
TM689-356

Figure 249. Alarm sensing circuit: alarm differential amplifier 17, alarm relay control 18A, simplified schematic diagram.

negative signals of *equal* amplitude to both grids. The application of a negative signal to V7B reduces the tube current through that tube and, because it acts as a cathode follower, increases the negative voltage appearing at the cathode by an amount approximately equal to the applied signal. This negative increase at the cathode effectively applies a positive signal to the grid of V7A, which nullifies the negative signal applied to this grid. Therefore, current flow through tube V7A remains at the same level, although a negative signal has been applied to its grid. Tube V7A acts as an amplifier only when there is a *difference* between the two grid voltages, and this circuit is called a differential amplifier.

(5) Under normal operating conditions, however, a highly negative signal is applied to the grid of V7A. Tube V7B continues to conduct although the negative signal applied to V7A is sufficient to cut off this tube. A voltage-divider network, R44, R81, and R45, is connected between the plate of V7A and —108-volt dc supply. With V7A cut off, the plate voltage is at a high positive potential and the voltage obtained at the arm of ALM SENS potentiometer R81 is positive and allows V8A to conduct (*c* below).

(6) These conditions are affected by the following situations:

- (*a*) Order-wire transmitter failure at the preceding station.
- (*b*) Radio transmitter failure at the preceding station.
- (*c*) An increase in microwave path attenuation or a decrease of radio receiver signal-to-noise ratio, which results in a main-channel output signal-to-noise ratio of less than 26 to 16 db.
- (*d*) Radio receiver failure.
- (*e*) Order-wire receiver failure.

(7) When the order-wire transmitter fails at the preceding station, no 6-mc subcarrier signal is present in the order-wire receiver, even though the radio receiver may be functioning properly. Under this condition, there is a zero output from the 2d limiter grid and from the alarm noise filter. With a zero output from the 2d limiter grid, V7A conducts and lowers its plate voltage; this causes the voltage at the arm of R81 to become negative.

(8) When the radio transmitter fails at the preceding station, no rf signal or 6-mc subcarrier is picked up by the radio receiver. In this case, the radio receiver puts out a high level of broad-band noise. When this occurs, there is a negative voltage at the output of the alarm noise filter approximately equal to the negative voltage output of the 2d limiter grid. This negative voltage is reflected as a positive signal at the grid of V7A ((4) above) and nullifies the negative signal at this grid permitting V7A to conduct. This causes the output voltage at the arm of R81 to become negative.

(9) When the 6-mc signal-to-noise ratio decreases below 8 to 12 db, the level of the 6-mc subcarrier is approximately equal to the level of the noise components. Under this condition, negative voltages are obtained at the output of both the 2d limiter grid and the alarm noise filter; the negative voltages permit V7A to conduct and again make the R81 output negative.

(10) When the radio receiver fails, there is no 6-mc signal or broad-band noise. Under this condition, a zero voltage output is obtained at the 2d limiter grid and at the alarm filter. Tube V7A conducts and the R81 output is negative.

(11) When the order-wire receiver fails because of tube or voltage failure, an alarm condition is set up, either because there is no 6-mc subcarrier and noise ((8) above) or because of the fail-safe feature.

c. Alarm Relay Control V8A (fig. 249). Tube V8A, one-half of a 2C51 twin diode, is the control tube for alarm relay K2. The grid of this tube is connected to the arm of R81 in the plate circuit of alarm differential amplifier V7. During normal operation, the voltage from R81 is positive, and current flows through tube V8A to actuate alarm relay K2. Under this condition, no alarm is transmitted. When any of the elements of the system fail (*b*(5)–(9) above), the voltage obtained from R81 is negative and V8A is cut off. This causes alarm relay K2 to release and initiate an alarm signal. If tube V8A, or any tube in the order-wire receiver other than V5, V6, or V9 fails, relay K2 releases and an alarm is initiated. This is the fail-safe feature of this unit.

d. Alarm Signal (fig. 248).

(1) When alarm relay K2 releases, —18-volt dc is applied through contacts 4 and 6 of switch S3, contacts 11 and 1 of relay K2, contacts 6 and 4 of switch S2, contacts 8 and 7 of switch S3, and through the REC terminals to the bells of the remote handsets. Ac BUZZER I 2 is actuated by the application of 115 volts dc to it through contacts 1 and 2 of switch S3, contacts 12 and 4 of relay K2, contacts 5 and 3 of switch S2, contacts 11 and 10 of switch S3, and contacts 4 and 12 of relay K3.

(2) In addition, when tube V7A changes from a cutoff to a conducting state and initiates the alarm, a negative 2-second pulse is transmitted through C34 and R86 to the order-wire transmitter. The duration of this pulse is determined by the time constant of C34 and R86. During this 2-second period, the order-wire transmitter carrier is cut off, causing actuation of the alarm circuit in the following receiver. This alarm circuit also initiates a 2-second pulse, which actuates the alarm circuit in the next station, and so on. After a period of 2 seconds, the order-wire transmitter at each station resumes its normal operation, and the alarm signal is discontinued. The alarm signal is maintained at the initiating station until the condition which causes the unbalance of the differential amplifier is corrected.

Note. For Order Wire Receiver R–543/TRC–29 on Order No. 1640–Phila–51 (serial No. 230–297) and Order No. 15739–Phila–55 (serial No. 298–417), the duration of the cutoff pulse applied to the suppressor grid of V4 is determined by the time constant of C34 and R17.

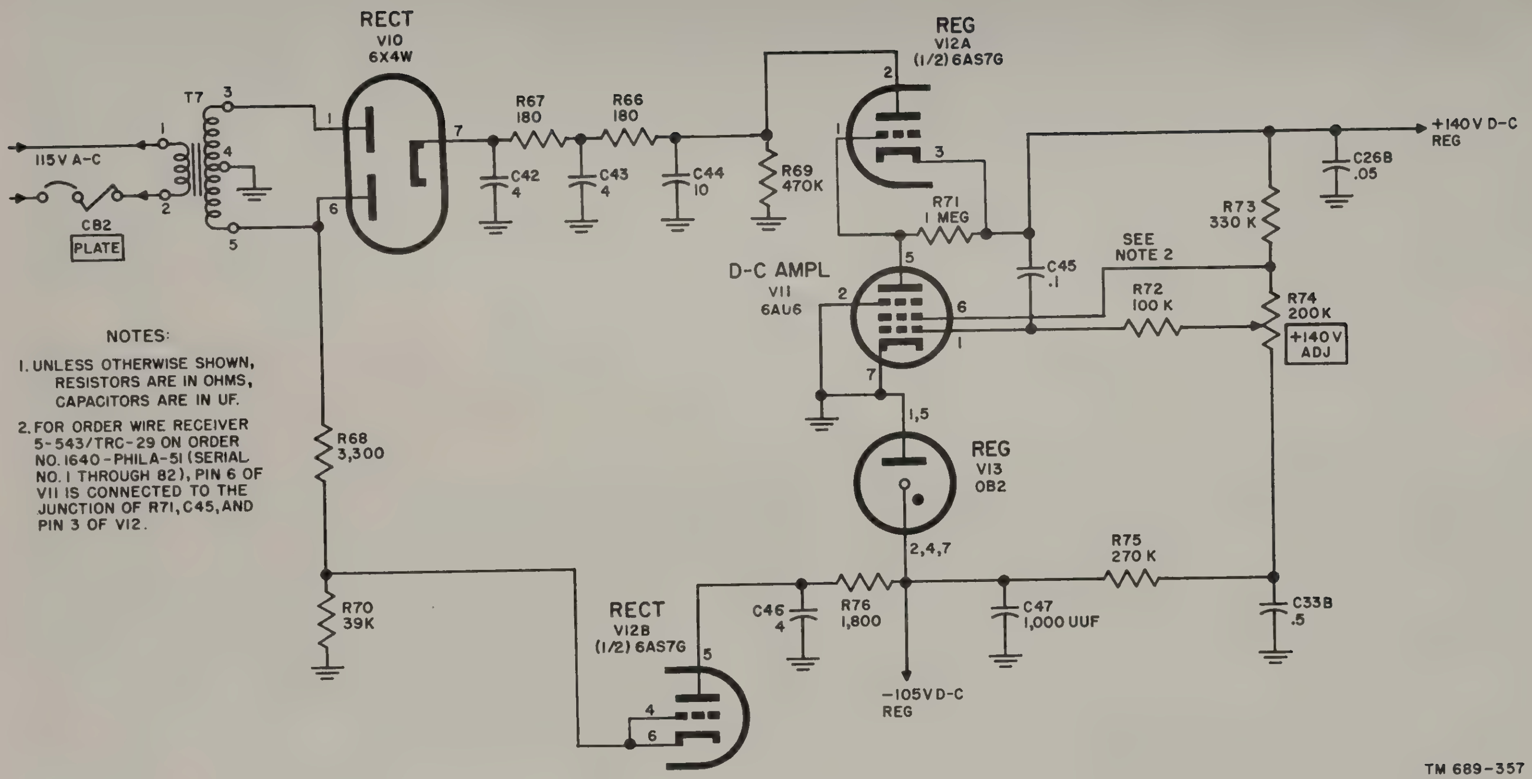
e. BUZZER CONTROL Switch, S2 (fig. 248). After an operator has become aware of the alarm condition, the continuous ringing of the handset bells and ac buzzer should be stopped by placing BUZZER CONTROL switch S2 in the MONITOR position. This disconnects the 115 volts ac from the buzzer and the —18 volts dc from the handset bells. However, if the failure is corrected while S2 is in the MONITOR position, alarm relay K2 is actuated and 115 volts ac is applied to the buzzer and —18 volts dc to the bells; this notifies the operator that the equipment once again is operating properly. The new 115-volt path is through contacts 1 and 2 of switch S3, contacts 12 and 5 of relay K2, contacts 1 and 3 of switch S2, contacts 11 and 10 or switch S3, and contacts 4 and 12 of relay K3. The new —18-volt path is through contacts 4 and 5 of switch S3, contacts 11 and 2 of relay K2, contacts 2 and 4 of switch S2, contacts 8 and and 7 of switch S3, and through the REC terminals to the handset bells.

188. Power Supplies

a. General. Necessary dc power for the vacuum tubes and the telephone and alarm circuits is supplied by power supplies included within the order-wire receiver chassis. Two basic supplies are used: a regulated supply that provides output voltages of 140 and —108 volts and an unregulated selenium rectifier supply that provides —10 and —18 volts for the telephone and ringing circuits.

b. Regulated Power Supply, V10 through V13 (fig. 250).

(1) *Rectifiers V10 and V12B.* Primary power to plate transformer T7 is applied through PLATE circuit breaker CB2. The secondary of this transformer feeds two rectifiers: V10, a 6X4W dual diode, and V12B, one-half of a 6AS7G twin triode, connected as a diode rectifier. Tube V10 is a full-wave rectifier, the output of which is filtered by C42, R67, C43, R66, and C44. Resistor R69 is a bleeder resistor. The output of this rectifier is fed to the plate of series regulator tube V12A. Part of the transformer output


RECT
V10
6X4W
REG
V12A
(1/2) 6AS7G
T7
115V A-C
CB2
PLATE
R67
180
R66
180
C42
4
C43
4
C44
10
R69
470K
R71
1 MEG
+140V D-C
REG
C26B
.05
R73
330 K
SEE
NOTE 2
C45
.1
D-C AMPL
V11
6AU6
R72
100 K
R74
200K
+140V
ADJ
REG
V13
OB2
1,5
2,4,7
R68
3,300
R70
39K
RECT
V12B
(1/2) 6AS7G
C46
4
R76
1,800
C47
1,000 UUF
R75
270 K
C33B
.5
-105V D-C
REG
TM 689-357

NOTES:

1. UNLESS OTHERWISE SHOWN, RESISTORS ARE IN OHMS, CAPACITORS ARE IN UF.
2. FOR ORDER WIRE RECEIVER 5-543/TRC-29 ON ORDER NO. 1640-PHILA-51 (SERIAL NO. 1 THROUGH 82), PIN 6 OF V11 IS CONNECTED TO THE JUNCTION OF R71, C45, AND PIN 3 OF V12.

Figure 250. Regulated power supply V10 through V13, simplified schematic diagram.

is taken at the junction of voltage-divider resistors R68 and R70 and applied to V12B. The half-wave negative rectifier output is filtered by C46, R76, and C47, and fed across V13. Resistor R76 also acts as a voltage-dropping resistor for V13 (an OB2), which varies its own resistance to maintain a constant 108-volt drop across the tube.

(2) *Voltage regulator circuits, V11 through V13.*

(*a*) The voltage regulator circuit includes three tubes which perform four functions. Tube V12A, one-half of a 6AS7G twin triode, is used as a series regulator. Dc control amplifier V11 is a 6AU6 pentode. An OB2 is used as the voltage reference tube and also furnishes a bias output of —108 volts; V12B, the other half of the 6AS7G twin triode, is used as a rectifier to furnish operating potential for V13.

(*b*) The circuit is conventionally arranged according to common series voltage regulator practice and contains one rather unusual feature. Voltage reference (and regulator) tube V13, instead of decreasing the available variable voltage between the output level and ground, is used here to increase that range and to permit a regulated output voltage lower than that obtainable from simple, conventional regulators. The tube is connected between the bottom of the control tube voltage divider and ground, with its cathode connected to the voltage divider and its plate grounded. An ac voltage is taken from voltage dividers R68 and R70 across one-half of the plate-supply transformer winding, and rectified by V12B, which is diode-connected. The output of this tube is about —130 volts dc. It is passed through an RC filter, in which C46 is the filter capacitor and R76 is the series resistor. Resistor R76 also serves as a voltage-dropping and current-limiting resistor for V13. The filter output is connected to the cathode of V13, establishing a fixed level of —108 volts dc at that point; this extends the voltage across the R73, R74, R75 voltage divider from +140 volts to —108 volts, or a total range of 248 volts. This allows the voltage at the grid of control amplifier V11 to be set at any point from approximately +38 volts to approximately —24 volts with respect to its cathode, which is grounded. Thus, an extremely wide range of control is obtained for the dc amplifier tube. This arrangement is necessary because the available voltage drop across series-regulator tube V12A is relatively small (85 volts).

(*c*) Resistors R68 and R70 are used as a voltage divider to reduce the voltage at the input of rectifier V12B. Capacitor C33B helps to filter the negative voltage applied to the divider. Resistor R71 is the plate load for V11, and R72 serves to isolate the V11 grid. Capacitor C45 improves the regulation of the supply against ripple and transient voltage waveforms. Capacitor C26B, across the output of the supply, reduces further the ripple content of the dc output voltage, and improves the decoupling of the supply from signal voltages in the various stages of the order-wire receiver.

(*d*) If the output voltage of the voltage regulator increases in voltage, a rise in the grid voltage of control amplifier V11 will occur and increase the current flow through the tube. The increased current flow causes a larger voltage drop across plate-load resistor R71; this results in a decreased voltage at the plate of V11. Because the plate of V11 is connected directly to the grid of series-regulator tube V12A, the grid voltage of V12A is reduced correspondingly. This increases the series resistance of V12A; its output voltage is reduced and it returns to its original assigned value of +140 volts, which has been set by +140V ADJ potentiometer R74.

Note. For Order-Wire Receiver R–543/TRC–29 bearing Order No. 1640–Phila–51 (serial No. 83–297) and Order No. 15739–Phila–55 (serial No. 298–417), the wiring of pin 6, V11, has been changed. The lead from pin 6 has been moved from the +140 V DC output to the junction of R73 and R74. This change was made to lower the screen voltage of V11 in order to improve regulation.

(*e*) If the output voltage decreases, the voltage at the grid of V11 decreases, and its plate voltage increases; the grid voltage of V12A increases, and the output voltage increases. If the input voltage from the rectifier fluctuates, similar actions take place and the output voltage is maintained at its normal value.

c. Telephone, Ring, and Filament Power Supply (fig. 251). Primary power is applied to filament transformer T6 through FIL circuit breaker CB1. Transformer T6 has two secondaries. One secondary is used to supply filament voltage to all the tubes in the order-wire receiver. The output of the other secondary feeds a full-wave bridge selenium rectifier, CR4, the output of which is filtered by R61, C40, R62, and C41. Resistor R64 is a bleeder. The —18-volt output is taken at the junction of R61 and R62 and is used for the ringing circuits. The —10-volt output required for talking current for the telephone handset transmitter is taken through R65 at the junction of R62 and R64.

189. Metering Circuits

Meter selector switch S1 in conjunction with meter M1 is used to check the overall performance of the order-wire receiver and is an aid in field alinement. The meter positions for normal operation and their functions are given in *a* through *f* below:

a. OW CARR LEVEL. In this position, the meter measures the voltage at the plate of differential amplifier V7A through meter resistors R42 and R41. When the meter reads 100, the correct 6-mc subcarrier signal is being received. When the meter reads 0, the 6-mc subcarrier level approximately equals the level of the 6-mc noise components from the radio receiver. This corresponds to the normal alarm trip point. A negative reading is obtained when the 6-mc noise components override the 6-mc subcarrier signal.

b. DISCR+ and DISCR—. In these positions, the meter monitors the dc output of discriminator V5 at the junction of R24 and R25. When the *average* of these two meter readings is other than zero, it indicates that either the local order-wire receiver discriminator or the order-wire transmiter at the preceding station is detuned. Two positions of reverse polarity are used for this measurement because the discriminator voltage may be negative or positive.

c. AUDIO. In this position, the meter measures the audio output voltage from the telephone transformer, T5. This signal is detected by CR1 and fed through meter resistor R4 to the meter. A reading of 100 on the meter corresponds to an audio output level of 0 dbm when

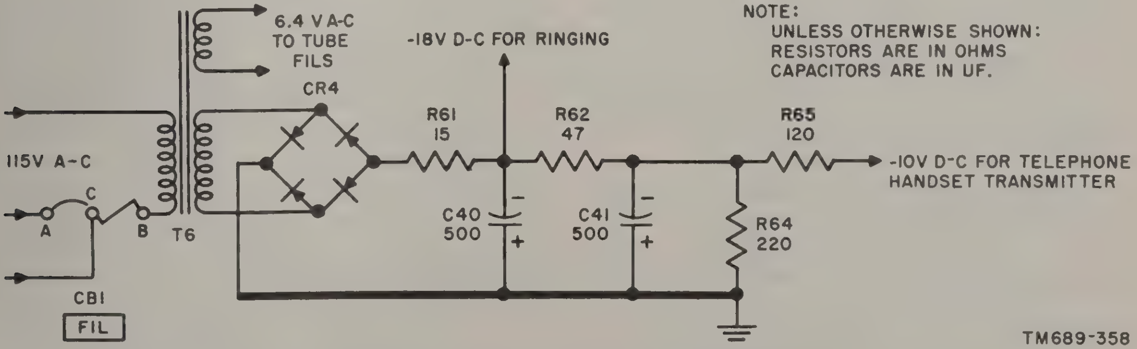


Figure 251. Telephone, ring, and filament power supply, simplified schematic diagram.

the received 6-megacycle signal is modulated with a 1-kc audio voltage at a frequency deviation of ±50 kc.

d. +140V. In this position, the meter measures the output voltage of the +140-volt supply through meter resistors R8 and R6.

e. DIV CONT LEVEL. In this position, the meter measures the output control voltage of diversity differential amplifier V9B, through meter resistors R58 and R55.

f. DIV OPER. In this position, the meter indicates which unit is furnishing the outgoing video voltage in diversity operation. The meter reading is 100 on the operating order-wire receiver; it is zero on the other unit. In normal operation, without diversity, the meter indication is zero.

190. Power Supply PP–690/G

a. General. The receiver power supply supplies dc power to the radio receiver. It contains two rectifier circuits, which provide the following regulated dc output voltages: +250 volts, +150 volts, +42 volts, —625 volts, —475 volts, and —300 volts. The output voltages are fed to terminals on terminal board TB3A from where they are fed to the radio receiver. The unit has two pilot lamps, which indicate that power has been applied to receiving equipment and that B+ voltage is being applied to the radio receiver. It also contains three circuit breakers for applying power to, and protection of, filament and plate transformers. The operation of the pilot lamps and circuit breakers is described in detail in paragraph 205.

b. Block Diagram Description (fig. 252).

(1) Power transformer T1 is used to convert the 115-volt ac line voltage to the voltage required for the +250-volt, +150-volt, and +42-volt rectifiers. Power transformer T3 converts the line voltage to the voltage required for the —675-volt, —475-volt, and —300-volt rectifiers.

(2) Rectifiers V1 and V2 and a filter network furnish dc voltage for the +250-volt supply. The output of the +250-volt supply is maintained constant by series-regulator tubes V8, V9, V10, V3A, and V11A (all connected in parallel), and dc control amplifier V12. Reference bias for V12 is provided by reference tube V13. Changes in input or output voltage in this supply are transmitted to the dc control amplifier grid through a voltage divider connected across the +250-volt output. The dc amplifier adjusts the resistance of the series regulators, which compensate for the change in voltage.

(3) Part of the +250-volt output voltage is fed to the +150-volt supply, which consists of series-regulator tubes V3B and V4 and dc control amplifier V5. Reference bias for V5 is provided by reference tube V7. This circuit operates in the same manner as one described for the +250-volt supply.

(4) Part of the output of the +150-volt supply is fed to regulator tube V6, which provides a regulated output of +42 volts.

(5) Rectifier V14 and rectifier-regulator tube V11B are connected in a voltage-doubler type circuit in which the magnitude of the voltage supplied by V11B is a function of the control voltage applied to its grid from dc amplifier V17. A reference voltage is applied to V17 by regulator-reference tubes V15 and V16. The output voltage of the voltage-doubler circuit is —625 volts. Any change in this voltage is transmitted to the dc amplifier which adjusts the resistance of V11B to compensate for the voltage change.

(6) Part of the —625-volt output is fed to regulator-reference tube V15 which provides a regulated output of —475 volts.

(7) Part of the —475-volt output is fed to another regulator-reference tube, V16, which, with a dropping resistor, provides a regulated output of —300 volts.

c. Detailed Circuit Description.

(1) *+250-volt regulated supply* (figs. 253 and 254).

(*a*) Tubes V1 and V2, both 5R4WGY diodes, are connected in a full-wave rectifier circuit (fig. 253) across the secondary winding of power transformer T1, which provides the necessary high voltage. The rectified output is taken at the filaments

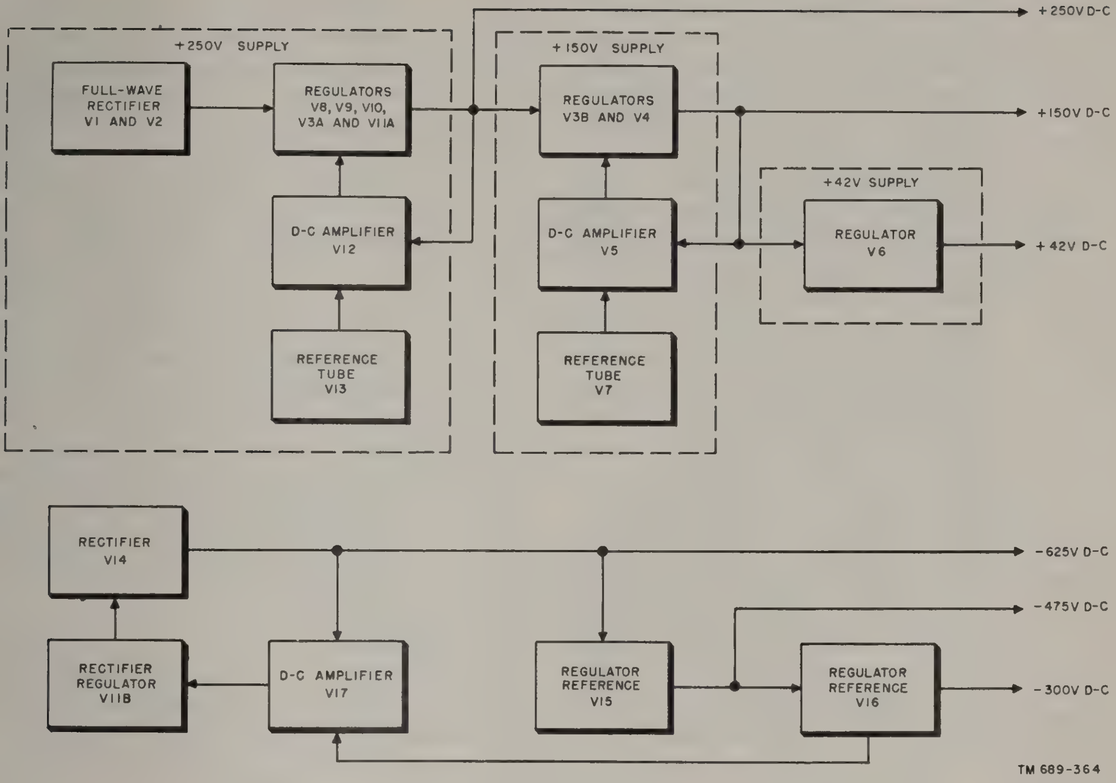

+250V SUPPLY
FULL-WAVE RECTIFIER V1 AND V2
REGULATORS V8, V9, V10, V3A AND V11A
D-C AMPLIFIER V12
REFERENCE TUBE V13
+150V SUPPLY
REGULATORS V3B AND V4
D-C AMPLIFIER V5
REFERENCE TUBE V7
+42V SUPPLY
REGULATOR V6
+250V D-C
+150V D-C
+42V D-C
RECTIFIER V14
RECTIFIER REGULATOR V11B
D-C AMPLIFIER V17
REGULATOR REFERENCE V15
REGULATOR REFERENCE V16
-625V D-C
-475V D-C
-300V D-C
TM 689-364

Figure 252. Power Supply PP–690/G, block diagram.

of V1 and V2 and fed to a pi-type filter consisting of inductor L1 and capacitors C1, C2, and C3. The filter output is applied to the series regulators of +250-volt supply.

(*b*) Series regulation of the filter output voltage is provided by eight triode sections, V8, V9, V10, V3A, and V11A, all connected in parallel. The +250-volt output voltage is taken from the cathode circuits by current-equalizing cathode resistors. The grid bias to each stage is obtained via a grid resistor from the plate of dc amplifier V12 (fig. 254).

(*c*) The voltage existing on the plate of the dc amplifier, a 6AU6 pentode, depends upon the bias voltage applied to its grid. This voltage is derived from the +250-volt line by a voltage-divider network comprised of resistors R31 and R33 and potentiometer R32. Potentiometer R32, +250V ADJ, is adjusted to provide a 250-volt output. The dc bias on this tube is stabilized by connecting the cathode to reference tube V13.

(*d*) Changes in potential at the cathodes of the regulator tubes result in a proportional change in the grid-cathode voltage of the dc amplifier, V12. The resultant change in current through plate-load resistor R34 of this tube changes the bias voltage applied to the grids of the regulator tubes. The change in grid voltage of the regulator tubes changes the impedance of these tubes so as to return the cathode voltage to its proper value. This supply operates similarly to the +300-volt supply described in paragraph 173*c*(1).

(*e*) Screen voltage for the dc amplifier is provided by a voltage divider comprised of resistors R35, R36, R37, and R38. The effects of transient changes are minimized by filter capacitor C4 and coupling capacitor C7; they transmit sharp transient voltage changes directly to the grid of V12 and improve the response of the regulator to such changes.

(2) *+150-volt regulated supply* (fig. 255).

(*a*) Part of the output of the +250-volt supply is fed to the +250-volt supply where this voltage is dropped to +150 volts by regulator tubes V3B and V4 and maintained at this voltage by dc control amplifier V5 (fig. 255). Reference voltage for the dc amplifier is provided by V7.

(*b*) The +250-volt and +150-volt regulators operate in identical manner, the only exception being that three triode sections, instead of eight, are used as series regulators in this +150-volt supply. Grid bias is obtained from the plate of V5 via grid resistors R1, R5, and R8.

(*c*) The grid bias of dc amplifier V5 is obtained from a voltage divider comprised of resistors R9 and R11 and +150V ADJ. potentiometer R10. This potentiometer is adjusted to provide a +150-volt output from the cathode circuit of the regulator tubes. Capacitor C5 improves the voltage-regulator response to fast changes in output voltage; capacitor C6 tends to filter out such transient voltages. Resistors R13 and R14 form a voltage divider for obtained proper-screen-grid voltage on tube V5. Resistor R12 is the plate-load resistor for V5.

(3) *Regulated supply, +42-volt.* Part of the output of the +150-volt supply is fed to regulator tube V6, an OB2, which drops the voltage by 108 volts dc provide a regulated output voltage of +42 volts.

(4) *Regulated supply, —625-volt* (fig. 256).

(*a*) Tubes V14 (a 5R4WGY) and V11B (one-half of a 6AS7G) are connected in a voltage-doubler type of cir-

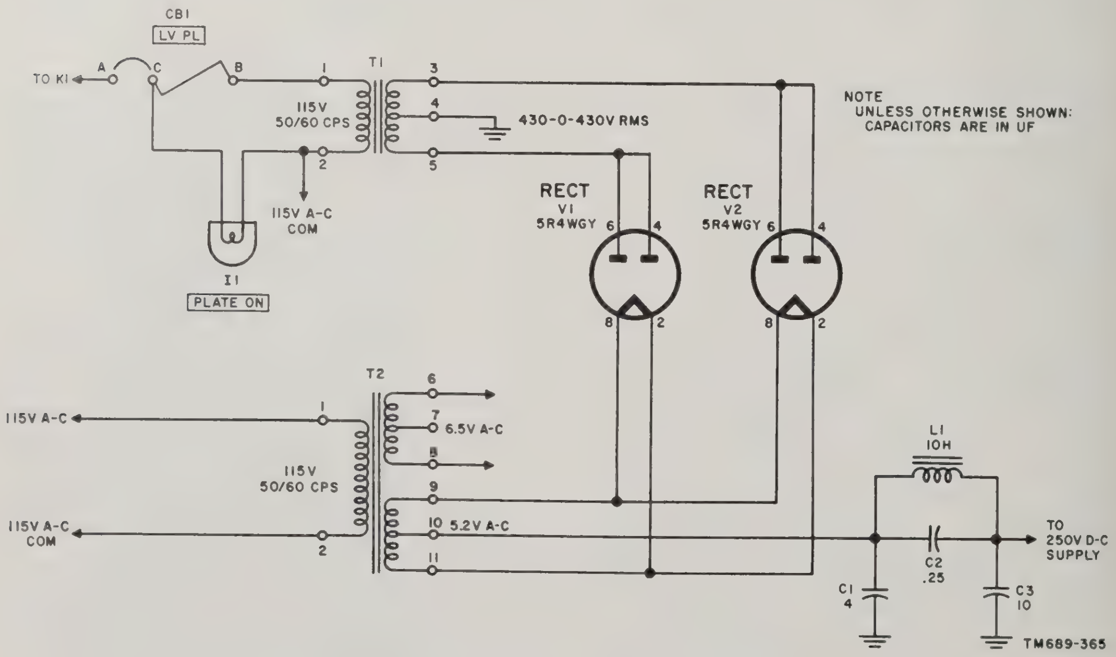

CB1
LV PL
TO K1
A
C
B
1
T1
3
4
5
115V
50/60 CPS
2
430-0-430V RMS
115V A-C
COM
I1
PLATE ON
RECT
V1
5R4WGY
6
4
8
2
RECT
V2
5R4WGY
6
4
8
2
NOTE
UNLESS OTHERWISE SHOWN:
CAPACITORS ARE IN UF
T2
6
7
6.5V A-C
8
9
10
5.2V A-C
11
115V A-C
1
115V
50/60 CPS
115V A-C
COM
2
L1
10H
C2
.25
C1
4
C3
10
TO
250V D-C
SUPPLY
TM689-365

Figure 253. Rectifier circuit, +250-volt supply, simplified schematic diagram.

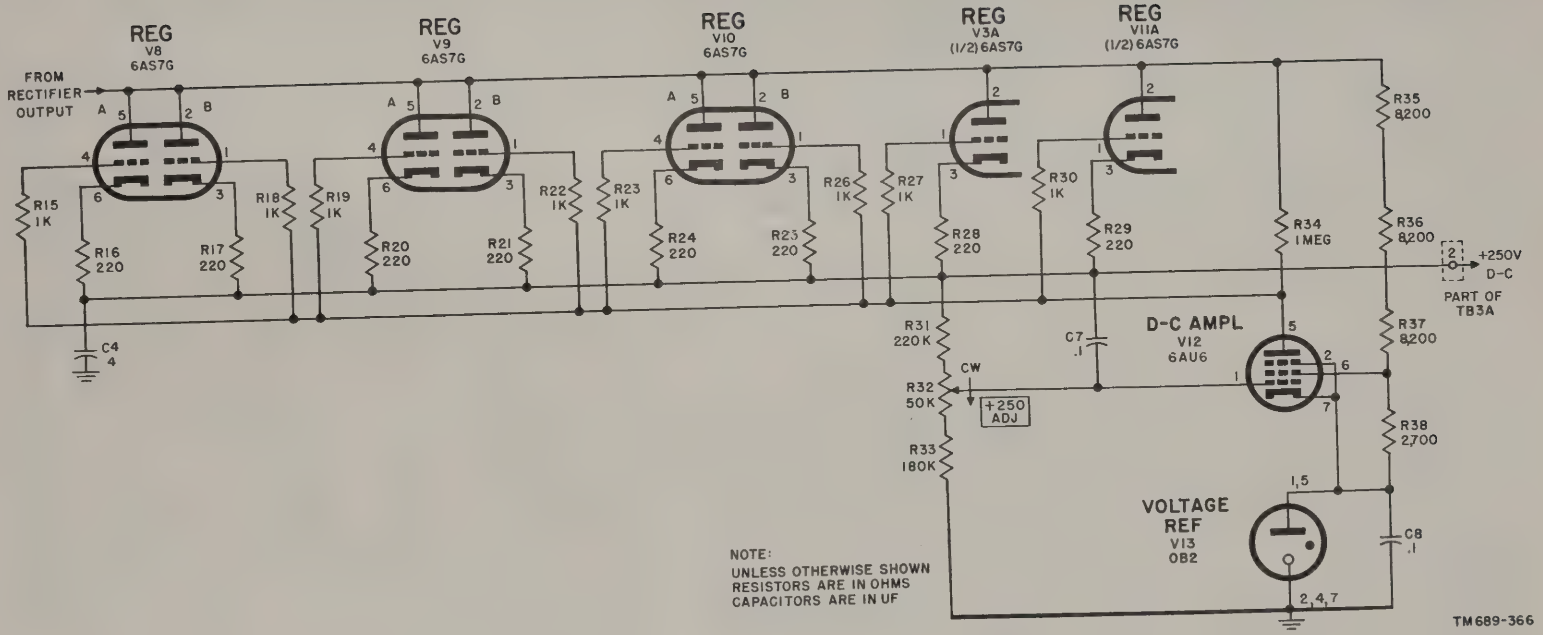

REG
V8
6AS7G
REG
V9
6AS7G
REG
V10
6AS7G
REG
V3A
(1/2) 6AS7G
REG
V11A
(1/2) 6AS7G
FROM
RECTIFIER
OUTPUT
A
5
2
B
4
1
6
3
R15
1K
R16
220
R17
220
R18
1K
R19
1K
R20
220
R21
220
R22
1K
R23
1K
R24
220
R25
220
R26
1K
R27
1K
R28
220
R29
220
R30
1K
R34
1MEG
R35
8,200
R36
8,200
R37
8,200
R38
2,700
2
+250V
D-C
PART OF
TB3A
C4
4
R31
220K
CW
R32
50K
+250
ADJ
R33
180K
C7
.1
D-C AMPL
V12
6AU6
7
VOLTAGE
REF
V13
OB2
1,5
2,4,7
C8
.1
NOTE:
UNLESS OTHERWISE SHOWN
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UF
TM689-366

Figure 254. Regulator circuit, +250-volt supply, simplified schematic diagram.

cuit. The secondary of power transformer T3 is applied to both tubes. During the positive half-cycle (terminal 3 with respect to terminal 4), V11B conducts and charges up capacitor C9 to a negative voltage, with respect to ground, equal to the peak applied voltage minus the voltage drop across V11B. During the negative half-cycle, V14 conducts and charges C10 to a voltage equal to the peak applied voltage minus the voltage drop across V14, with a polarity that is negative at the junction of C10 and plates of V14 and positive at the junction of C10 and C9. The negative voltage developed across C9 (during positive half-cycle) is added to the voltage developed across C10 (during negative half-cycle), and this sum voltage is applied to a filter comprised of L2, C11, and C12. Consequently, the voltage obtained at the output of this filter is equal to approximately twice the peak applied voltage minus voltage drops in tubes V14 and V11B and is negative with respect to ground.

(*b*) The voltage drop across tube V11B is controlled by dc amplifier V17 (a 6AU6) which provides the grid bias for V11B. The grid bias of the dc amplifier is obtained from a voltage divider comprised of resistors R43 and R45 and BEAM V ADJ. potentiometer R44. Potentiometer R44 is adjusted to provide a —625-volt regulated output from this supply. Resistor R39 serves as the plate load for V17; screen voltage is obtained from a voltage divider comprised of resistors R40 and R41. A floating reference bias is applied to the cathode of V17 through reference tubes V15 and V16.

(*c*) A change in the —625-volt output voltage results in a proportional change in the grid bias of V17. The resultant change in the plate current of R39 of this tube causes a corresponding voltage change in the bias of V11B. The voltage drop across V11B changes so as to return the —625-volt output voltage to its proper value.

(5) *—475-volt regulated supply.* Part of the output of the —625-volt supply is

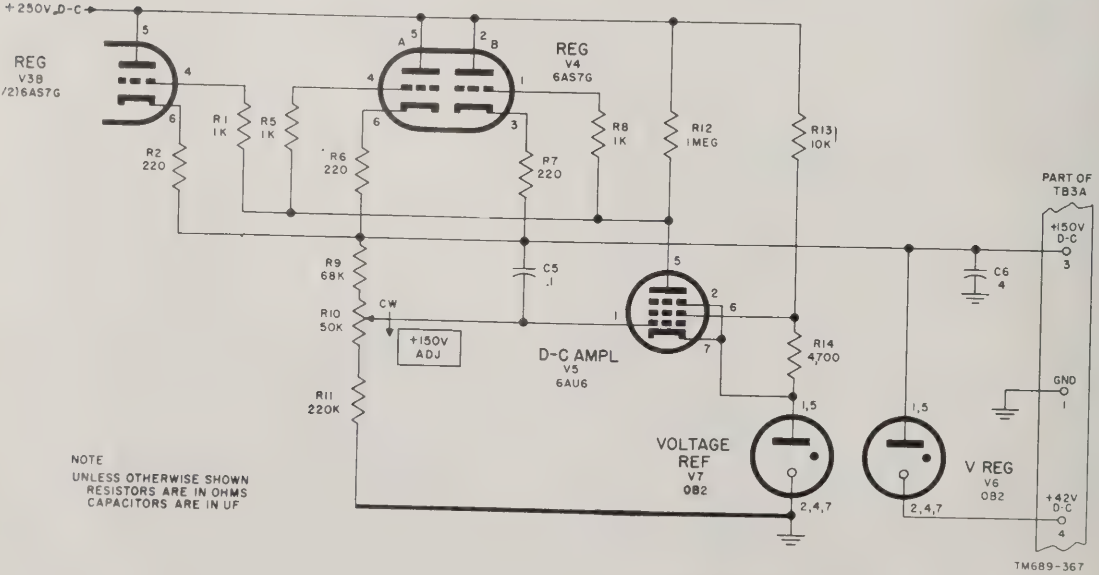
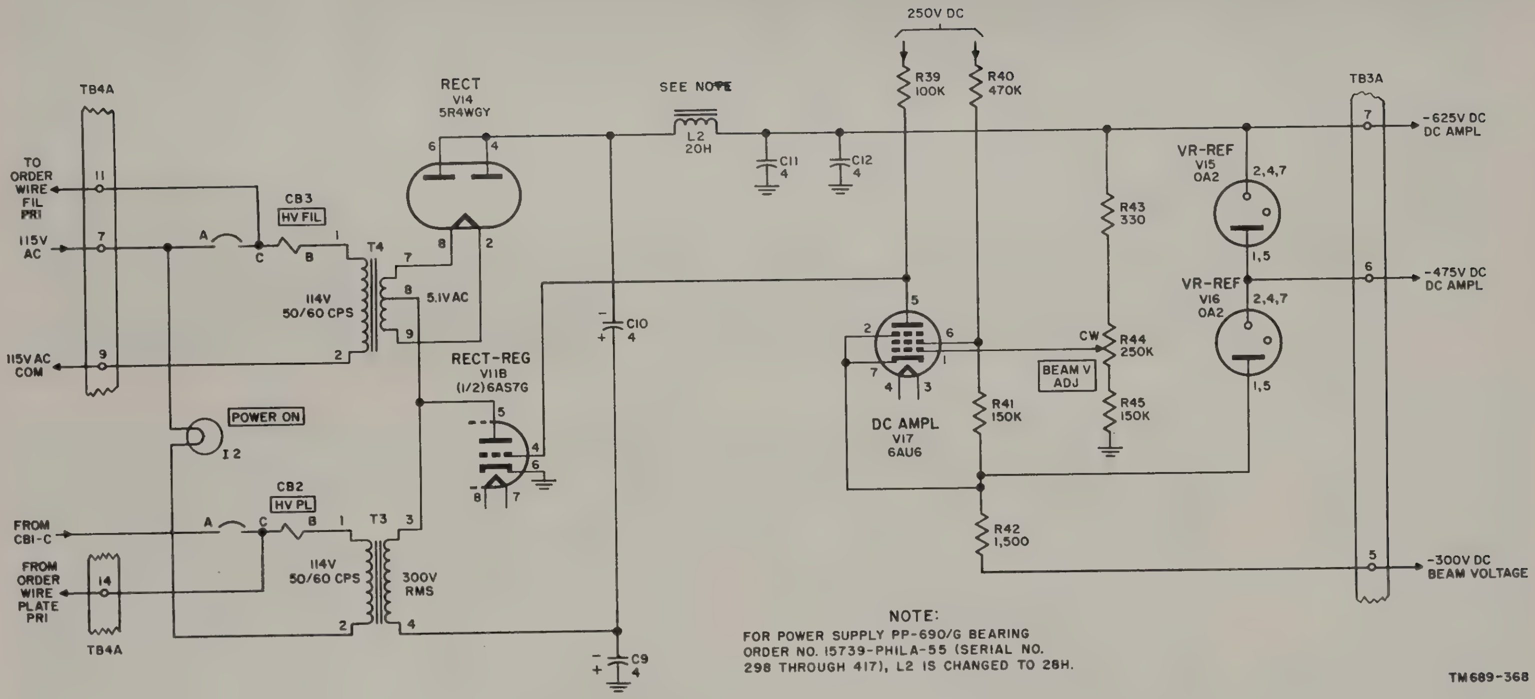

+250V D-C
REG
V3B
(1/2)6AS7G
5
4
6
R1
1K
R5
1K
R2
220
A
5
2
B
REG
V4
6AS7G
4
1
6
3
R6
220
R7
220
R8
1K
R12
1MEG
R13
10K
PART OF
TB3A
+150V
D-C
3
R9
68K
C5
.1
C6
4
5
2
6
1
7
R10
50K
CW
+150V
ADJ
D-C AMPL
V5
6AU6
R14
4,700
GND
1
R11
220K
1,5
1,5
VOLTAGE
REF
V7
0B2
V REG
V6
0B2
2,4,7
2,4,7
+42V
D-C
4
NOTE
UNLESS OTHERWISE SHOWN
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UF
TM689-367

Figure 255. +150-volt and +42-volt supply, simplified schematic diagram.


TB4A
TO ORDER WIRE FIL PRI
11
115V AC
7
115V AC COM
9
A
C
CB3
HV FIL
B
1
T4
114V 50/60 CPS
2
7
8
9
5.1VAC
RECT
V14
5R4WGY
6
4
8
2
POWER ON
I2
FROM CBI-C
FROM ORDER WIRE PLATE PRI
14
TB4A
CB2
HV PL
A
C
B
1
T3
3
114V 50/60 CPS
300V RMS
2
4
RECT-REG
V11B
(1/2)6AS7G
5
4
6
8
7
C10
4
C9
4
SEE NOTE
L2
20H
C11
4
C12
4
250V DC
R39
100K
R40
470K
5
2
6
1
7
4
3
DC AMPL
V17
6AU6
R41
150K
R42
1,500
R43
330
CW
R44
250K
BEAM V ADJ
R45
150K
VR-REF
V15
OA2
2,4,7
1,5
VR-REF
V16
OA2
2,4,7
1,5
TB3A
7
-625V DC DC AMPL
6
-475V DC DC AMPL
5
-300V DC BEAM VOLTAGE

NOTE:
FOR POWER SUPPLY PP-690/G BEARING ORDER NO. 15739-PHILA-55 (SERIAL NO. 298 THROUGH 417), L2 IS CHANGED TO 28H.

TM689-368

Figure 256. —625-volt, —475-volt, and —300-volt supplies, simplified schematic diagram.

fed to regulator tube V15, which drops the voltage by 150 volts to provide a regulated output voltage of —475 volts.

(6) *—300-volt regulated supply.* Part of the output of the —475-volt supply is fed to regulator tube V16, which drops the voltage by 150 volts to —325 volts. This voltage is further dropped by resistor R42 to about —300 volts.

Section IV. ANTENNA SYSTEM

191. General
(fig. 257)

The antenna system transmits the microwave signal generated by the transmitter to the next station and receives the signal transmitted by that station and feeds it to the receiver. The output of the transmitter is fed to either duplexer, which directs the energy to the surface-wave transmission line. The signal is transmitted through this transmission line to the antenna. Similarly, energy picked up by the antenna is transmitted down the surface-wave transmission line to the duplexer. The duplexer then directs the received energy to the receiver input.

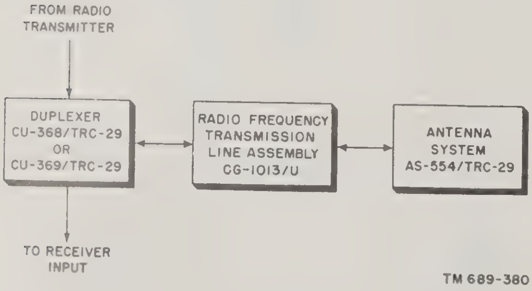

FROM RADIO TRANSMITTER
DUPLEXER CU-368/TRC-29 OR CU-369/TRC-29
RADIO FREQUENCY TRANSMISSION LINE ASSEMBLY CG-1013/U
ANTENNA SYSTEM AS-554/TRC-29
TO RECEIVER INPUT
TM 689-380

Figure 257. Antenna system, block diagram.

192. Duplexer
(fig. 258)

a. The duplexer enables the use of a single transmission line and antenna system for both transmitting and receiving. However, use of the duplexer also greatly limits the combination of transmitter-receiver frequencies that can be used at a radio set as illustrated in figure 32 and described in paragraph 39*e*(3). To increase the number of transmitter-receiver combinations there are two duplexers available. Whenever possible, the transmitter and receiver frequencies are selected so that one of these duplexers can be used. However, if this is not possible, the equipment may be operated without a duplexer, if the requirements indicated in paragraph 39*f*(2) are met. It is necessary to have separate antenna and surface-wave transmission line systems for transmitting and receiving when operating without a duplexer.

b. The duplexer contains two coaxial line filters, one a low pass filter and the other a high pass filter. The low pass filter passes any energy in the low pass band, that is, 1,700 to 1,993 mc (channels 1 to 8) for Duplexer CU–268/TRC–29 and 2,050 mc (channels 1 to 14) for Duplexer CU–369/TRC–29. It presents an extremely high impedance to any energy in the high pass band, that is, 2,050 to 2,400 mc (channels 15 to 27) in Duplexer CU–368/TRC–29 and 2,165 to 2,400 mc (channels 20 to 27) in CU–369/TRC–29. Similarly, the high pass filter passes energy in the high pass band and presents an extremely high impedance to energy in the low pass band.

c. As illustrated in figure 258 there are three receptacles on the duplexer. One, marked ANTENNA, connects to the surface-wave transmission line. The other two, marked CHANNELS 1–8 and CHANNELS 15–27 on the Duplexer CU–368/TRC–29, are connected to the transmitter output and receiver input. If the receiver is operating on channel 3 and the transmitter on channel 20, the receiver input is connected to the CHANNELS 1–8 receptacle and the transmitter output to the CHANNELS 15–27 receptacle.

d. This means that channel 20 signals from the transmitter are passed through the high pass filter and fed to the antenna. These signals are blocked from entering the receiver input by the low pass filter. Similarly, channel 3 signals, picked up the antenna and fed to the duplexer, are passed through the low pass filter to the receiver and are blocked from entering the transmitter by the high pass filter.

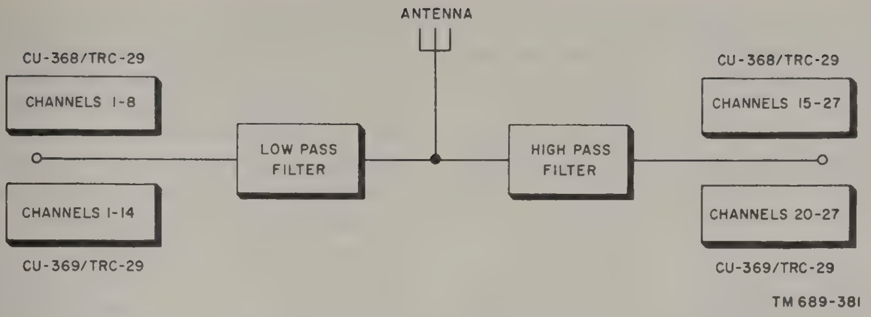


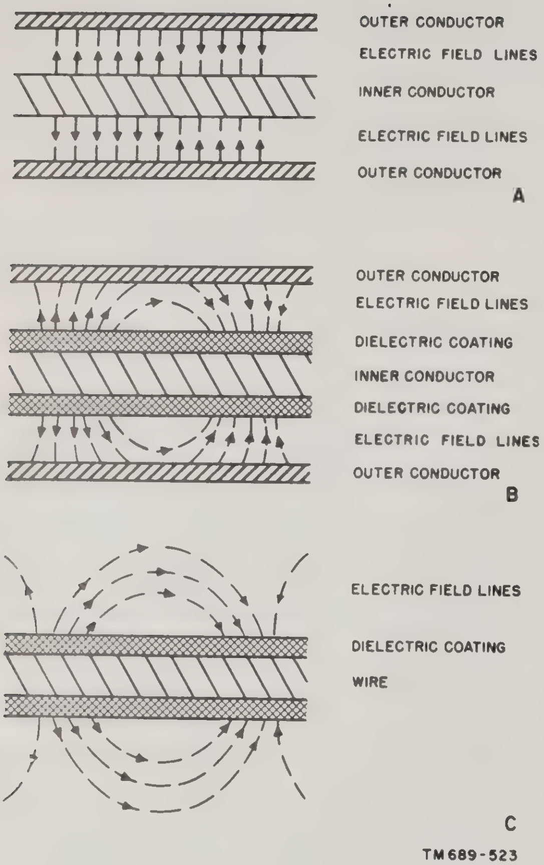
Figure 258. Duplexer, block diagram.

193. Radio Frequency Transmission Line Assembly CG–1013/U

a. General. The cable assembly is used to transmit the rf energy from the duplexer to the antenna and vice versa. The surface-wave transmission line (SWTL) wire, forming a major component of Radio Frequency Transmission Line Assembly CG–1013/U, is a relatively new type of low-loss transmission line which employs a single dielectric coated conductor as a wave-conducting means. The problem is one of reducing the radiation loss normally present so that the line will not act as a long-wire antenna. The nonradiating wave mode is brought about by the resistivity of the wire. A perfectly conducting wire would not guide a nonradiating wave. The finite conductivity causes a reduction in the phase velocity of the radio energy field, compared to the free-space velocity, and it is this reduction in phase that establishes conditions rendering nonradiating wave propagation feasible. If the phase velocity can be reduced enough, for instance by covering the surface of the wire with a dieletric layer, the nonradiating wave becomes stable and can be excited more easily and with a high degree of efficiency.

b. Wave Development. The functioning of the SWTL is best understood if it is compared with a coaxial line to which it is closely related. Neglecting the effect of finite conductivity, the guided wave is a transverse electric and magnetic wave that propagates with the velocity of light (A, fig. 259). If the space between the inner and outer conductor is filled with a dielectric material, the wave is unchanged, but the velocity of transmission is reduced. If the inner conductor is covered with a dielectric that only partially fills the space, the velocity will be intermediate between a solid dielectric line and an air-filled line. An important modification of the electric field occurs as shown in B, figure 259. The field lines become curved and some of them no longer reach the outer conductor. If the diameter of the outer conductor is increased while the inner conductor and its dielectric sheath are unchanged, more of the return current does not reach the outer conductor. If the outer conductor is large enough, conduction current along the outer tube becomes practically zero. Thus, the outer conductor becomes unnecessary (C, fig. 259). To form a practical line, this mode must be the only mode excited on the line. The preceding explanation suggests a method of exciting this mode. Starting from a coaxial line section, the inner conductor of which has a dielectric coat, the diameter of the outer conductor is gradually increased until it is so large that it has no appreciable effect on the field. In this manner, a coaxial wave is gradually changed to a guided wave. In practice, it is convenient to expand the coaxial line somewhat before introducing the dielectric coating. Thus, the dielectric cover of the wire need extend only to the tip of the launcher and no cover on the taper section is required.

c. Line Loss. As the outside of the coaxial cable is enlarged while keeping the same center conductor, the impedance of the line is raised, and the loss is reduced because less current is generated in the higher impedance for a given power transmission. The SWTL has an impedance of 200 to 400 ohms and, therefore, the loss in such a line is a fraction of that of an ordinary coaxial cable with the same size inner conductor. Compared with a 2-wire line of the same



A—Coaxial line
B—Partial dielectric line
C—Surface-wave transmission line

Figure 259. Field distribution.

impedance and the same wire size, the loss is about half, because dissipation occurs in only one wire rather than in two wires. The dielectric coat introduces slightly greater loss than would be expected from the open-wire line by comparison. For this reason, the dielectric material must be chosen for low-loss characteristics at the desired operating frequency. The SWTL of Radio Frequency Transmission Line Assembly CG–1013/U has a loss of approximately 1 db per 100 feet at 2,500 mc.

d. Radiation Loss. Such a direct comparison of losses between the SWTL application and coaxial lines is not quite fair as there is a radiation loss inherently connected with the formation of the surface wave. This loss, which is substantially independent of the length of the line, depends on the design of the launchers and their physical size. Because of this launching loss, which is usually in the order of 1 db for both terminations, the SWTL cannot compete with ordinary transmission lines if they are so short that their loss is about 5 db or less. For longer lines, this launching loss becomes of little importance and the superiority of the SWTL becomes apparent. Compare a 200-foot SWTL with a loss of 6 db with connecting cables to an RG–17/U line of 14 db loss. The amplitude distribution of the expanded field at the mouth of the horn must match the normal amplitude of the surface wave. This is particularly true if the horn diameter is too large and there is in addition the possibility of exciting undesirable radiation modes within the horn mouth. The launching horn loss appears as a radiated field pattern from the horn. The field pattern from this horn is similar to that of a similar horn antenna radiating one-tenth the power. Maximum coupling to this horn launcher from interfering rf fields occurs when the interfering field is vertically polarized. For this reason, to reduce the mutual coupling between the different portions of a 2-frequency link, all operating antennas should be horizontally polarized (approximately 20 db reduction). The launcher casting is designed to match a 50-ohm transmission line to the several hundred ohm impedance of the SWTL. In order to provide continuity for the de-icing current from the SWTL to the launcher housing, a quarter wave (shorted coaxial stub) matching section is provided between the coaxial fitting and the end of the launcher casting. The design of this quarter-wave section limits the launcher to 1,700 to 2,400 megacycle applications.

e. Climatic Effects. Being an open wave-guiding line, the SWTL is subject to weather conditions, but to a degree less than open 2-wire lines. Rain and dry snow have little effect. Droplets of water on the line however act as small radiating dipoles and increase the loss of the line. Such droplets form on lines that are nearly horizontal but are no problem on vertical installations at 2,400 megacycles. The formation of ice is more serious and must not be allowed to form on the lines. In contrast to twin leads, a water film or a layer of soot has little effect since the electric field is almost perpendicular to the dielectric surface. With twin leads, such a layer forms a conduction path between the two conductors thereby introducing high attenuation. The de-icing assembly will remove the ice or prevent its formation when approximately 40 amperes flows in the wire. Do not let the current exceed 60 amperes or overheating will result during above-freezing operation. The de-icing assembly should be turned on only during the periods when ice is expected to form which is during a relatively narrow temperature range from 20° to 33° air temperature. A disadvantage of the SWTL is its susceptibility to bends or kinks, which convert the guided mode to a radiating mode and introduce loss and cross coupling. A 30° bend will introduce a radiation loss of one-half db or more.

f. Coupling. Little cross coupling is experienced between the guided modes on two parallel lines. The attenuation between lines varies from 45 db at 2 feet to 60 db at 6 feet. A separation of 10 feet will reduce the coupling from this factor to a value sufficiently low to permit normal failure alarm operation on Radio Set AN/TRC–29 links. When installing, it is important to prevent excitation of radiating modes in nearby metal objects, inasmuch as radiation coupling will rapidly raise the cross talk between the two directions of 2-frequency links. All metal objects should therefore be kept at least 5 feet from the line at all times. Coupling from the line and launchers to an external rf field is 45 db below the AN/TRC–29 antenna with vertical polarization and 65 db with horizontal polarization.

194. Antenna AS–554/TRC–29

a. The antenna is a horn-fed parabolic-reflector antenna, which may be mounted on a suitable structure such as Tower AB–216/U. The orientation of the feed horn can be rotated to provide either vertical or horizontal polarization. The 8-foot reflector beams the energy in the direction perpendicular to the plane of the antenna providing an antenna gain of about 30 db.

b. Figure 260 shows the horizontal radiation pattern of this antenna. The beamwidth is about 4.5° at the half-power (or 3-db) points. The ratio of the maximum power point in the major lobe to the maximum power point in any of the minor lobes is more than 200:1, that is, the major-to-minor lobe ratio is greater than 23 db.

Section V. ACCESSORIES

195. General

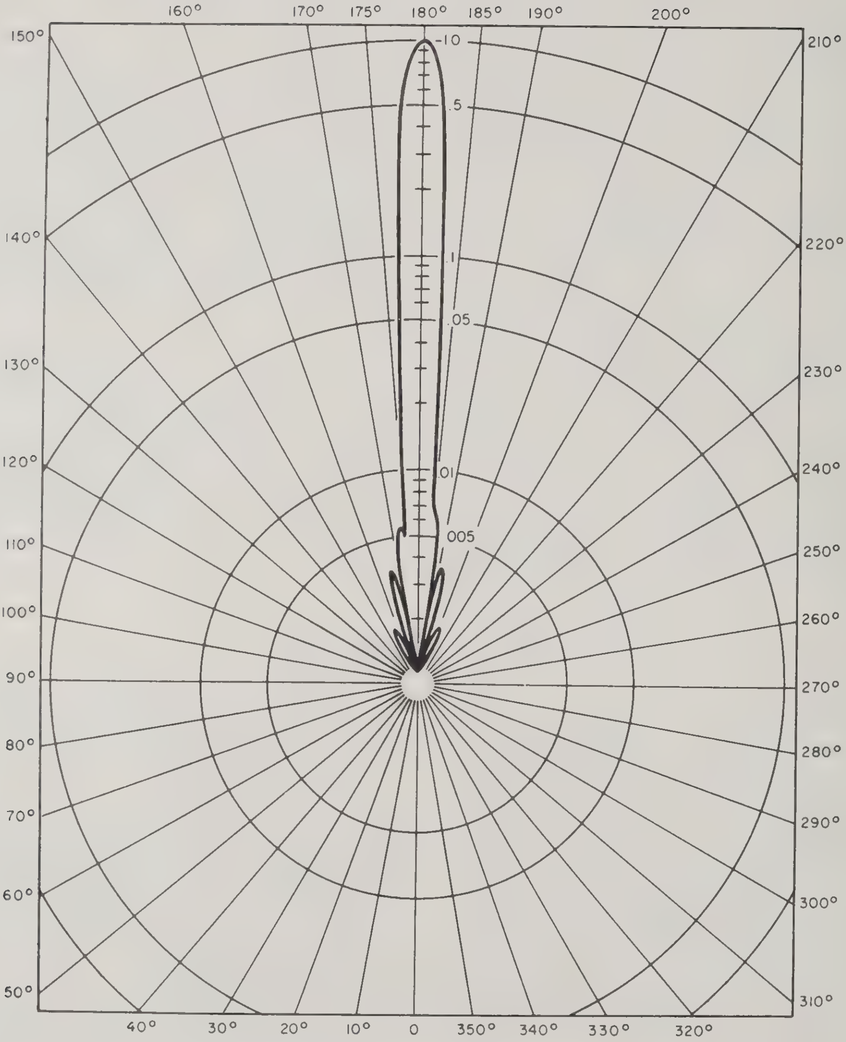
The accessories supplied with Radio Set AN/TRC–29 are the switch box autotransformer and the remote handset. The switch box is used when there are two sources of primary power from which to select. The autotransformer is used to provide a nominal 115-volt primary-power output voltage for input voltages in the range of 100 to 130 and 200 to 260 volts. The remote handset is used at a station.

196. Switch Box SA–357/G
(fig. 261)

The switch box permits the selection of one of two power sources. Generally the autotransformer output is connected to 115/230 VAC INPUT 2 receptacle J4 and the alternate power source is connected to 115/230 VAC INPUT 1 receptacle J3. INPUT SELECTOR SWITCH S1 is then placed in the *2* position so that the autotransformer output is fed to both 115/230 VAC OUTPUT receptacles J1 and J2, which are connected in parallel. The primary power connection for Radio Set AN/TRC–29 is made to one of these jacks, while the other jack is used for any utility power that may be required at the station. A GND CONN post is connected to a suitable ground stake and is the common ground connection for all equipment located at a station, including the video equipment.

197. Autotransformer

The autotransformer is used when the primary power source is other than 115 volts ac. Two input jacks are provided: 230V INPUT jack J4 is used for line voltages between 200 and 260 volts, and 115V INPUT jack J5 is used for line voltages between 100 and 130 volts. The line voltage used is fed through a circuit breaker to autotransformer T1. The autotransformer and its taps are designed so that a 115-volt output (within 4 volts) can be obtained. The prop-



TM 689-422

Figure 260. Antenna radiation pattern.

er voltage tap is selected by INCREASE OUTPUT switch S1. The 115-volt nominal output is available at 4 KVA MAX. LOAD 115V OUTPUT receptacle J3. The autotransformer is designed for a maximum load of 4 kva. The autotransformer output voltage is indicated by the LINE VOLTS meter in the radio transmitter and can also be measured across the OUTPUT VOLTAGE TEST jacks, J1 and J2, on the autotransformer. The voltages shown in figure 262 are those measured between winding taps with either 115 or 230 volts input.

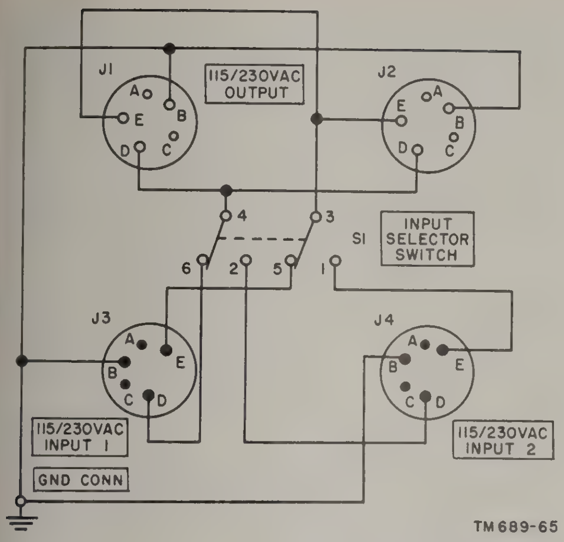

J1
A
B
C
D
E
115/230VAC OUTPUT
J2
A
B
C
D
E
4
3
S1
INPUT SELECTOR SWITCH
6
2
5
1
J3
J4
115/230VAC INPUT 1
115/230VAC INPUT 2
GND CONN
TM689-65

Figure 261. Switch box, schematic diagram.

198. Handset-Signaling Unit H–102/TRC–29
(fig. 263)

The remote handset is used for order-wire channel communication and ringing. This unit is described in detail in paragraph 186*d*(4).

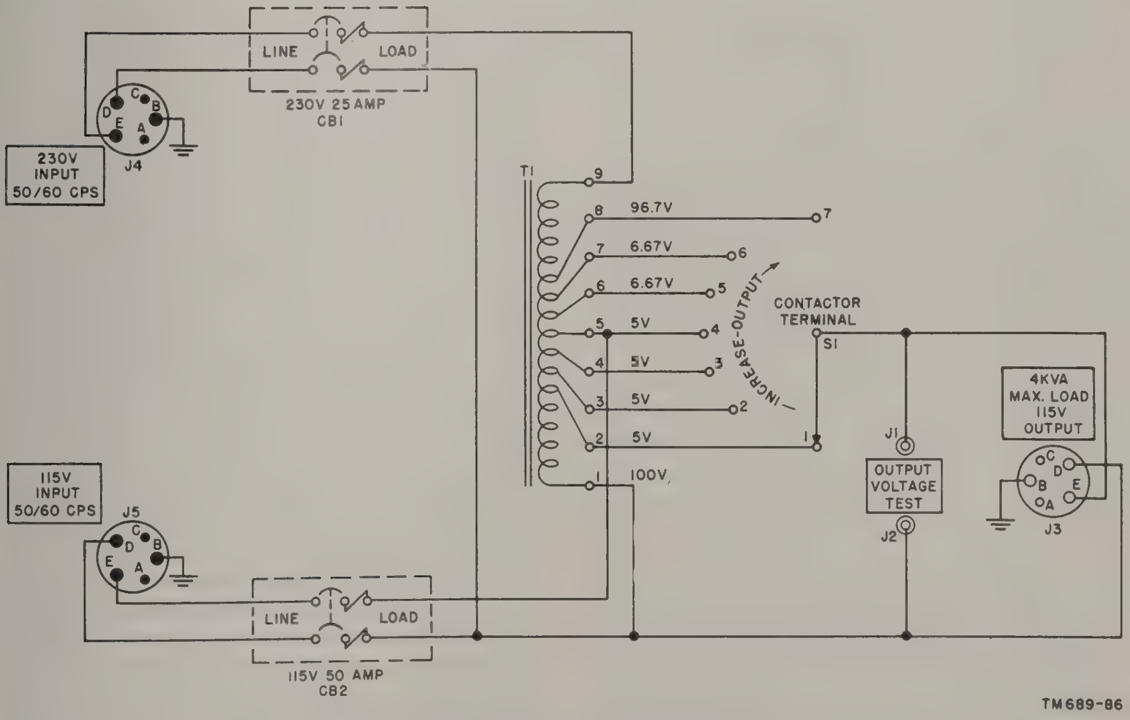

LINE
LOAD
230V 25 AMP
CB1
C
D
B
E
A
230V INPUT 50/60 CPS
J4
T1
9
8
96.7V
7
7
6.67V
6
6
6.67V
5
5
5V
4
4
5V
3
3
5V
2
2
5V
1
1
100V
INCREASE-OUTPUT
CONTACTOR TERMINAL
S1
4KVA MAX. LOAD 115V OUTPUT
J1
OUTPUT VOLTAGE TEST
J2
J3
115V INPUT 50/60 CPS
J5
LINE
LOAD
115V 50 AMP
CB2
TM689-86

Figure 262. Autotransformer, schematic diagram.

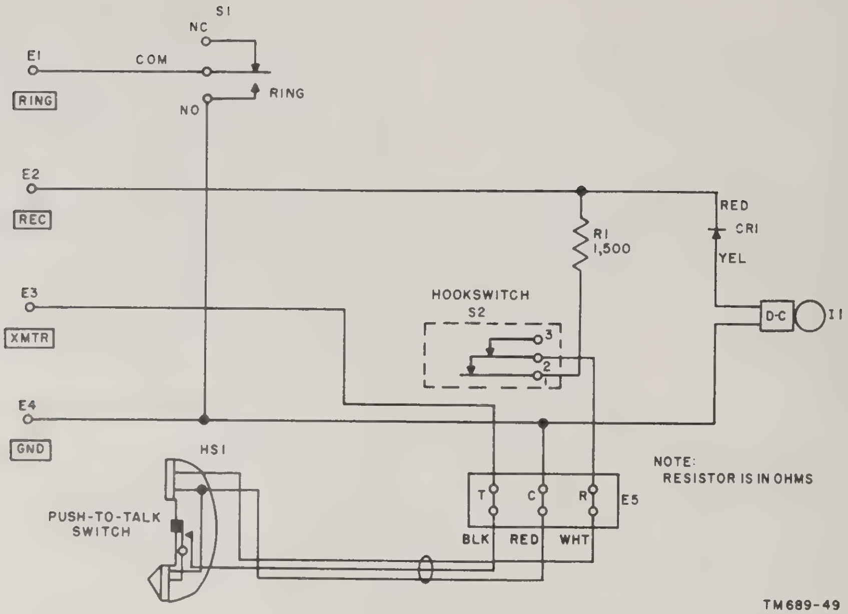


Figure 263. Handset-Signaling Unit H–102/TRC–29.

Section VI. ALARM AND RING-DOWN FACILITIES OF RADIO RELAY SYSTEM

199. General

a. Provision has been made in the radio set for transmitting alarm and ring-down signals in the order-wire channel (pars. 186 and 187). This section briefly summarizes the operation of the alarm and ring-down circuits in the individual set and then traces the transmission of these signals through the radio relay system.

b. The alarm facilities of the radio set include circuitry that will operate with suitable switchover equipment to switch automatically to a stand-by radio set when an alarm condition exists in the operating radio set. The switchover facilities provided by the radio set are described in paragraph 202.

200. Alarm System

a. Failure of any component of a radio set or the existence of a poor signal-to-noise ratio at any station (as detected in the order-wire receiver) in the radio relay system causes the initiation of an alarm signal. The alarm signal in the case of a receiver consists of a continuous ring at the station detecting the alarm condition and *only one* 2-second ring at every station following the point of detection of the radio relay system terminal. That is, if a failure occurs in an east-west signal, the 2-second alarm signal is transmitted east-to-west to all stations west of the initiating station until it reaches the west terminal. No alarm signal is transmitted east of the initiating station and, of course, this signal is not heard in the east terminal. If the transmitter fails, the TRANSMITTER OPERATING lamp goes off.

b. Figure 264 is a simplified schematic of the circuit indicating an alarm or ring-down signal. A brief summary of the operation of this circuit is given below to describe its application in the overall system operation.

c. With the equipment operating normally, V7A is cut off by a bias developed by the detected order-wire subcarrier signal. A failure in the order-wire transmitter, radio transmitter, or antenna in the preceding station, or the antenna system, radio receiver, or order-wire receiver in the station being described causes an alarm condition permitting V7A to conduct. When V7A conducts, the plate voltage drops and a negative pulse is transmitted through C34 and R86, across R63, and to the suppressor grid of V4 in the order-wire transmitter. This negative pulse is of sufficient amplitude to cut off this stage and thereby cut off the subcarrier output of the order-wire transmitter.

Note. For Order-Wire Receiver R–543/TRC–29 on Order No. 1640–Phila–51 (serial No. 230–297) and Order No. 15739–Phila–55 (serial No. 298–417), the following should be substituted for *c* above:

With the equipment operating normally, V7A is cut off by a bias developed by the detected order-wire subcarrier signal. A failure in the order-wire transmitter, radio transmitter, or antenna in the preceding station, or the antenna system, radio receiver, or order-wire receiver in the station being described causes an alarm condition permitting V7A to conduct. When V7A conducts, the voltage across the voltage divider, consisting of R44, R81, and R45, becomes more negative. Since the control grid of V8A is connected to the voltage divider, it too will be driven negative. This negative voltage will be high enough to cut off tube V8A. When tube V8A is cut off, alarm relay K2 is deenergized. This causes the —18 volts, which is derived from the telephone supply rectifier through contacts 2 and 11 of alarm relay K2, to be removed from the junction of C34, R86, and R87. Instead, —54 volts, which is obtained from the —108 volt bias supply through the voltage divider R86 and R87, then appears at the same point. Thus, when relay K2 is deenergized the voltage appearing at C34 drops from —18 to —54 volts and a—36-volt pulse is coupled through C34 to the suppressor grid of V4 (in the order-wire transmitter). This negative pulse is of sufficient amplitude to cut that tube off.

d. With the order-wire transmitter signal cut off, a subcarrier signal cannot be detected in the next station; hence, V7A in the order-wire receiver of this station is permitted to conduct, and it cuts off the subcarrier signal of its order-wire transmitter. In this manner, the signal is transmitted from one station to the next until it reaches the terminal.

e. The cutoff pulse transmitted from the plate of V7 (in the order-wire receiver) to the suppressor grid of V4 (in the order-wire transmitter) has a duration which is a function of the C34–R86–R17 (in the order-wire transmitter) time constant. After a period of about 2 seconds, capacitor C34 discharges enough to permit V4 to conduct and the order-wire transmitter operates normally. This removes the alarm condition from the next station which, in turn, removes it from the succeeding station and so on. After about 2 seconds, the alarm signal is removed at each of these latter stations.

Note. For Order-Wire Receiver R–543/TRC–29 on Order No. 1640–Phila–51 (serial No. 230–297) and Order No. 15739–Phila–55 (serial No. 298–417), the first sentence of *e* above should be changed to read as follows:

The duration of the cutoff pulse applied to the suppressor grid of V4 (in the order-wire transmitter) is determined by the time constant of C34 and R17 (also in the order-wire transmitter).

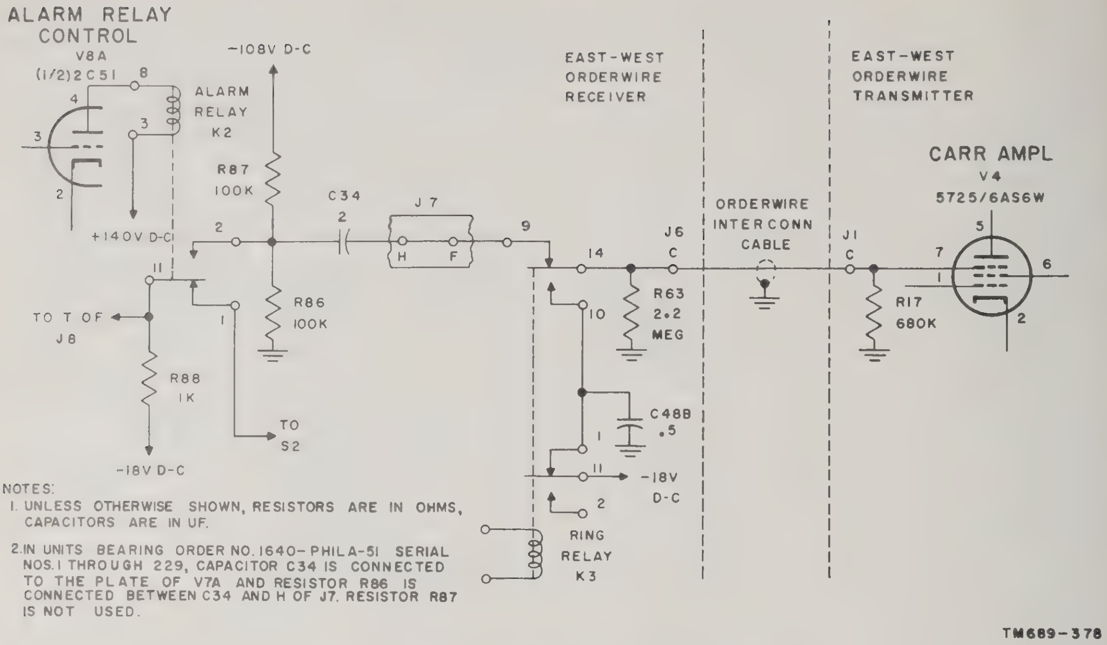
f. When tube V7A in the order-wire receiver conducts, it operates an alarm sensing circuit that operates the local buzzer and remote handset bell. At the initiating station, this tube conducts as long as an alarm condition exists, and the buzzer and bell operate continuously. However, at the succeeding stations, the alarm condition lasts only 2 seconds (as described above), after which period, each station returns to its normal operating condition. Consequently, the buzzer and bell sound for a period of only 2 seconds in these stations.

201. Ring-Down System

a. Ring-down is initiated by pressing the RING button on the order-wire receiver or the remote handset. Whenever the RING button is pressed, an up to 1-second ring is transmitted in both directions to every station in the radio relay system.

b. When the RING button or remote handset pushbutton is pressed, relay K3 is operated. The negative voltage across capacitor C48B in the order-wire receiver is applied across resistor R63 and from there to the suppressor grid of V4 of the order-wire transmitter. This cuts off the order-wire transmitter for a period of about 1 second (time constant of C48B and R17 in the order-wire transmitter) if the RING button is pressed for over 1 second. If the RING button is released before 1 second, the ring stops when the button is released.

c. With the order-wire transmitter cut off for 1 second, an alarm condition exists in the following station, which actuates its buzzer and cuts off the order-wire transmitter in that station. In this manner, the 1-second ring signal is transmitted down the radio relay system. Pressing the RING button applies a negative signal to both the east-west and west-east order-wire receivers; therefore, this ring-down signal is transmitted in both directions and all stations in the radio relay system receive it.


ALARM RELAY CONTROL
V8A
(1/2)2C51
-108V D-C
ALARM RELAY K2
R87 100K
C34
J7
H
F
EAST-WEST ORDERWIRE RECEIVER
ORDERWIRE INTERCONN CABLE
EAST-WEST ORDERWIRE TRANSMITTER
CARR AMPL
V4
5725/6AS6W
+140V D-C
J6
C
J1
C
TO T OF J8
R86 100K
R63 2.2 MEG
R17 680K
R88 1K
TO S2
C48B .5
-18V D-C
-18V D-C
RING RELAY K3
TM689-378

NOTES:
1. UNLESS OTHERWISE SHOWN, RESISTORS ARE IN OHMS, CAPACITORS ARE IN UF.
2. IN UNITS BEARING ORDER NO. 1640-PHILA-51 SERIAL NOS. 1 THROUGH 229, CAPACITOR C34 IS CONNECTED TO THE PLATE OF V7A AND RESISTOR R86 IS CONNECTED BETWEEN C34 AND H OF J7. RESISTOR R87 IS NOT USED.

Figure 264. Alarm and ring-down simplified schematic.

202. Switchover Facilities
(fig. 265)

a. General.

(1) Facilities have been incorporated in the radio set to operate with appropriately designed switchover equipment. When connected for switchover operation, a standby radio set is provided for each operating set. A failure on the operating radio set will be detected by the switchover equipment, which will then automatically place the standby set into operation to replace the defective equipment.

(2) The switchover equipment monitors separately the transmitting and receiving equipments of Radio Set AN/TRC-29. This is necessary, because in any one complete communication link, the signal is transmitted by the transmitter at one station and picked up by the receiver at the next station. By monitoring transmitting and receiving equipment separately, it is possible to actuate the switchover at the station at which the failure occurs. A failure of the transmitting equipment results in a signal failure in the subsequent receiving system. Consequently, receiver switchover is delayed sufficiently to permit the transmitter to switchover first if trouble is in the transmitting system. In this event (transmitter defective), switchover corrects the trouble and the receiver switchover is not effected. However, if the trouble is *not* in the transmitter and *is* in the receiving system, the receiver switchover takes place after the time-delay period.

b. Transmitter Switchover Facilities (fig. 265).

(1) Switchover of the transmitting system is effected by opening the interlock circuit in the defective equipment and completing the interlock path in the standby equipment. The interlock path in the transmitting system is completed through pins C and D of jack J3 in the order-wire transmitter. Connection is made between these pins only when a primary power ready volt-

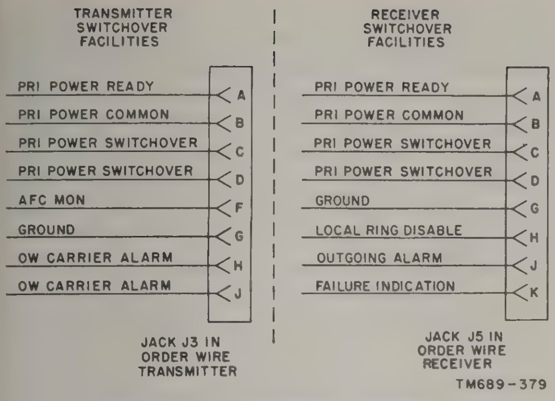

TRANSMITTER SWITCHOVER FACILITIES
PRI POWER READY
PRI POWER COMMON
PRI POWER SWITCHOVER
PRI POWER SWITCHOVER
AFC MON
GROUND
OW CARRIER ALARM
OW CARRIER ALARM
A
B
C
D
F
G
H
J
JACK J3 IN ORDER WIRE TRANSMITTER
RECEIVER SWITCHOVER FACILITIES
PRI POWER READY
PRI POWER COMMON
PRI POWER SWITCHOVER
PRI POWER SWITCHOVER
GROUND
LOCAL RING DISABLE
OUTGOING ALARM
FAILURE INDICATION
A
B
C
D
G
H
J
K
JACK J5 IN ORDER WIRE RECEIVER
TM689-379

Figure 265. Switchover facilities.

age, proper AFC MON, and OW CARRIER ALARM signals are obtained at pins A and B, F and G, and H and J, respectively, of jack J3.

(2) The ready voltage is applied to pins A and B only if all the interlocks and circuit breakers in the transmitting system are closed. The proper AFC MON voltage is obtained as long as the transmitter frequency is within certain prescribed limits. The proper OW CARRIER ALARM signal is obtained if the overall transmitting system is operating properly. If the proper ready voltage is not obtained when the equipment is turned on, or if after the equipment is operating the AFC MON or OW CARRIER ALARM deviates from prescribed limits, the primary power connection between pins C and D is opened and such a connection is made in the standby equipment (which normally does not connect pins C and D), which energizes this equipment.

c. Receiver Switchover Facilities (fig. 265).

(1) Switchover from the preferred to the standby equipment is accomplished by opening the interlock path in one equipment and closing it in the other. The interlock path is completed through pins C and D of jack J5 in the order-wire receiver. Connection is made between these pins when the proper signal is applied to pins A and B, and proper voltage is applied to pin K.

(2) Ready voltage is applied when all interlocks and switches are closed. Proper voltage is applied to pin K as long as the proper signals are monitered in the alarm differential amplifier of the order-wire receiver. Defective operation of the receiving system causes the removal of the failure indication voltage at pin K and operates the switchover equipment. The switchover equipment will also have facilities for transmitting a coded alarm signal which is applied through pin J.

Section VII. PRIMARY POWER SYSTEMS

203. General

There are two basic primary power distribution systems in the radio set that are virtually independent of each other. One primary power distribution system covers all the transmitting equipment, including the order-wire transmitter, transmitter, low-voltage power supply, high-voltage power supply; and the other covers all of the receiving equipment including the order-wire receiver, radio receiver, and receiver power supply. The high-voltage power supply also acts as the distribution point for all ac primary power. That is, the primary power enters the high-voltage supply, and from there it is branched to the transmitting and receiving systems.

204. Transmitter Primary Power System (fig. 266)

a. Input Circuit. Figure 266 is a ladder schematic diagram showing the distribution of power in the complete transmitter equipment. The ac input to the whole system enters the high-voltage power supply at pins D and E of receptacle J1. Pin D of J1 is designated as the common side, while terminal E is the high side. It is in the high side of the input line that all control of the primary power circuits, such as circuit breaking or interlocking, takes place.

The input primary power obtained at pins D and E of J1 branches into two paths: one supplies power to convenience outlets J4, J5, J6, and J7 through fuses F1 and F2, and the other supplies power to the equipment through circuit breakers CB1 and CB2 (INPUT POWER BREAKER). Outlets J2 and J3 in the latter branch supply ac power to the receiver and auxiliary equipment.

b. Application of POWER Circuit Breaker CB1.

(1) Leads from D and E of J1 connect to terminals 13 and 12, respectively, of TB3A in the high-voltage power supply. The common lead, terminal 13, then branches out to the various units comprising the transmitter. Terminal 12 (high side) connects directly through the interconnecting cable to main circuit breaker CB1 in the radio transmitter. This breaker controls *all* primary power in the transmitting system.

Figure 266. Transmitter primary power circuits, ladder schematic diagram.
(Contained in separate envelope)

(2) The switch position of this breaker and all others following are in series so that power is applied in sequence. The sequence is: filament power, bias, low voltage, and then high voltage. When circuit breaker CB1 in the radio transmitter is closed, the high side of the primary powerline is applied through terminal 11 of TB3 in the high-voltage power supply to filament transformer T5, which supplies filament power for all tubes in the radio transmitter. Green pilot light I 1 in the high-voltage power supply will light to indicate that power is on.

c. Application of HV FILAMENT and LV FILAMENT Circuit Breakers. When CB1 is closed, power is applied to terminal 7 of TB3 in the high-voltage power supply and from there to CB4 (HV FILAMENT) in the high-voltage power supply. When CB4 is closed, power is applied to T1 (the high-voltage power supply filament transformer) and to CB3 (LV FILAMENT). When CB3 is closed, power is applied to transformer T1 in the low-voltage power supply, which supplies filament power for this supply. The green FIL ON lamp in the low-voltage power supply then lights. With CB3 closed, power is also applied to time-delay relay K2 through contacts of relay K1 (normally closed). The heating element in this relay will take 60 seconds to warm up enough to close its normally open switch.

d. Application of FIL Circuit Breaker.

(1) When CB3 is closed, power is also applied to circuit breaker CB2 (FIL) in the order-wire transmitter. This applies primary power to order-wire filament transformer T5 (via terminal 3, TB3 in high-voltage power supply to terminal 9, TB1 in order-wire transmitter).

(2) Primary power is also applied to interlock switch S3 in the order-wire transmitter when CB2 is closed. The interlock system that links the four chassis in the system begins here. When the equipment is in switchover operation (TRANSFER CONTROL), connection from the interlock switch to terminal 6 of TB1 (in order-wire transmitter) is made through terminals C and D of jack J3, which are shorted in the switchover equipment. Under these conditions, TRANSFER CONTROL ON light I 1 in the order-wire transmitter goes on. When switchover is not used, switch S4 (MANUAL OPERATE) is closed, and connection to terminal 6, TB1, is made through the contacts of this switch. From terminal 6, TB1, the interlock circuit goes to terminal 7, TB4, of the radio transmitmitter; interlock switch S10; terminal 9, TB3 (radio transmitter); terminal 1, TB3 (high-voltage power supply); pin K, jack J8 (high-voltage power supply); pin K, jack J1 (low-voltage power supply); interlock switch S1 (low-voltage power supply); pin J, jack J1 (low-voltage power supply); pin J, jack J8 (high-voltage power supply); and through interlock switch S1 (high-voltage power supply) to time-delay relay K2 and relay K1.

e. Operation of Time-Delay Relay K2. When all filament circuit breakers and interlock switches are closed, ac power is applied to the switch in the time-delay relay and at a stationary contact of the switch in relay K1. Ac power is applied to the heater of relay K2 when the LV FILAMENT circuit breaker is closed. After the heating element warms up and closes its associated switch, ac power is applied to the coil of K1, which closes two contacts. One contact provides a holding voltage for the K1 coil. The second contact connects ac power to BIAS V–150V circuit breaker CB5 and removes ac power from the heating element of K2. Relay K1 remains closed by the holding voltage applied to its coil. This relay is constructed to close its two switches for about 3 seconds in the event of momentary failure or interruption of the input primary power. In the event of a longer failure, the relay releases and the initial warm-up cycle must be repeated when ac is reapplied.

f. Application of BIAS V–150V, LV PLATE, and KLYSTRON HV Circuit Breakers.

(1) Closing of circuit breaker CB5 (BIAS V–150V) applies primary power through its coil to pin L, jack J8 (high-voltage power supply) ; pin L, jack J1 (low-voltage power supply) ; and to transformer T3, the bias voltage transformer. Primary power is also fed to circuit breaker CB6 (LV PLATE). When CB6 is closed, power is applied to low-voltage plate transformer T2 via pins P on jacks J1 (low-voltage power supply) and J8 (high-voltage power supply). When power is applied to this transformer, red PLATE ON (low-voltage power supply) lamp I 2 goes on.

(2) Power is also supplied to circuit breaker CB7 (KLYSTRON HV). When CB7 is closed, red HV PLATE ON lamp I 2 (high-voltage power supply) goes on. Power is applied to transformer T2 (high-voltage power supply), which is the klystron high-voltage transformer through S2 (PA PLATE VOLTAGE ADJUST position). It is also applied to klystron blower B2 in the radio transmitter, through terminal 9 of TB3 (high-voltage power supply) and through terminal 6 of TB3 (radio transmitter). This ready voltage is applied to the switch-over equipment only after all circuit breakers and interlock switches are closed.

g. Application of PA PLATE and PLATE Circuit Breakers.

(1) After CB7 is closed, power is connected to circuit breaker CB8 (PA PLATE). In the normal operating position, PA PLATE VOLTAGE ADJUST—KLYSTRON BEAM VOLTAGE TEST ADJUST switch S2 (high-voltage power supply) is in PA PLATE VOLTAGE ADJUST as shown in figure 266. With S2 in this position, power is applied to T3, a variable transformer, when CB8 is closed. The output of this transformer is then fed to transformer T4, the power amplifier voltage transformer, through switch S2.

(2) Switch S2 is only used in the alternate position (KLYSTRON BEAM VOLTAGE TEST ADJUST) when a new klystron is to be broken in for a short time at reduced voltages. In this case, T3 is first adjusted down to the zero point with circuit breakers CB7 and CB8 open. Switch S2 is then placed in the KLYSTRON BEAM VOLTAGE TEST ADJUST position, and circuit breakers CB7 and CB8 are closed. This applies the output of T3 to the klystron high-voltage transformer through contacts of switch S2. Under these conditions, a lower than normal output voltage can be obtained from the klystron high-voltage supply.

(3) When circuit breaker CB8 is closed, power is also applied to terminal 8, TB3 (high-voltage power supply) ; to terminal 10, TB3 (high-voltage power supply) ; terminal 8, TB1 (order-wire transmitter) ; and to CB1 (PLATE). When this circuit breaker is closed, power is supplied to transformer T4, the order-wire plate voltage transformer. Primary power is also supplied to the ready line of the switch-over equipment through pin A of jack J3.

205. Receiver Primary Power
(fig. 267)

a. Figure 267 is a ladder schematic diagram showing the distribution of power in the complete receiver equipment. Primary power for the receiving equipment is applied to pins B (common) and C of jack J1 115V AC INPUT in the receiver power supply. From these pins, power is applied to the buzzer in the order-wire receiver via terminals 3 and 15 (common) of TB4 (power supply), terminals 2 and 8, TB1 (order-wire receiver), fuse F1, and contacts of ring relay K3. One side of the primary powerline is also applied to POWER circuit breaker CB1 in the radio receiver via terminals 6 of TB4 (power supply) and 8 of TB1 (radio receiver).

b. When POWER circuit breaker CB1 in the radio receiver is placed in the ON position, primary power is applied to transformer T2, indicator lamp I 2 (POWER ON), and CB3 (HV FIL), in the power supply via terminals 6 and 7 of TB1 (radio receiver) and 8 and 7 of TB4 (power supply). Transformer T2 supplies filament power for all filaments in the radio receiver.

Figure 267. Receiver primary power circuits, ladder schematic diagram.
(Contained in separate envelope)

c. When the HV FIL circuit breaker is placed in the ON position, primary power is applied across transformer T4 (power supply), which supplies filament power to the tubes in the power supply. Actuation of this circuit breaker also connects one side of the primary powerline to circuit breaker CB1, FIL (order-wire receiver), via terminals 11 of TB4 (power supply) and 6 of TB1 (order-wire receiver), and a contact of relay K1 (power supply).

d. When the FIL circuit breaker in the order-wire receiver is placed in ON position, primary power is applied to transformer T6 (order-wire receiver), which supplies filament power to all tubes in the order-wire receiver. Primary powerline is at the same time connected to the coil of relay K1 (power supply) via contacts of SERVICE SELECTOR switch S3 (order-wire receiver), interlock switch S4 (order-wire receiver), terminal 9 of TB1 (order-wire receiver), terminal 2 of TB1 (radio receiver), interlock switch S4 (radio receiver), terminal 5 of TB1 (radio receiver), terminal 5 of TB4 (power supply), and interlock switch S1 (power supply). Primary power cannot be applied to relay K1 unless all filament switches are on and all interlock switches are closed.

e. Application of power to relay K1 closes its contacts and connects one side of the primary powerline to CB1, LV PL (power supply). When this circuit breaker is placed in the ON position, primary power is applied to PLATE ON indicator lamp I 1 (power supply) and transformer T1 (power supply), which supplies voltage to the positive regulated supplies. At the same time, one side of the primary powerline is also connected to circuit breaker CB2, HV PL (power supply).

f. When the HV FIL circuit breaker is placed in the ON position, primary power is applied to transformer T3 (power supply), which supplies high-voltage power for the negative power supplies. At the same time, one side of the primary powerline is also connected to circuit breaker CB2, PLATE (order-wire receiver), via terminals 14 of TB4 (power supply) and 7 of TB1 (order-wire receiver).

g. When the PLATE circuit breaker is placed in ON position, primary power is applied across transformer T7 (order-wire receiver), which supplies voltage for the order-wire receiver power supply. Application of this circuit breaker also completes the primary power connections across the RECEIVER ON indicator lamp I 1 (radio receiver) via terminals 10 of TB1 (order-wire receiver) and 3 of TB1 (radio receiver). The other side of this indicator lamp is connected to the common buss in the power supply unit via terminals 4 of TB1 (radio receiver) and 9 of TB4 (power supply). PLATE power cannot be applied to the order-wire receiver unless all the other circuit breakers in the receiving equipment are in ON position, and the RECEIVER ON lamp lights only when all receiving equipment circuit breakers are on.

Section VIII. DIVERSITY OPERATION

206. Introduction

a. Diversity Reception. Diversity reception is the term applied to a system of reception of radio signals in which two receivers, each with its own antenna, are used to receive the same transmitted signal, and in which the output of the receiver providing the better signal is automatically selected for use in the radio system. The purpose is to minimize the effects of fading on the received signal because of changing propagation phenomena. Radio Set AN/TRC–29 uses two sets of receiving equipment and two sets of antenna equipment. Each set of receiving equipment is permanently connected to one of the sets of antenna equipment. Both antennas are beamed in the same direction, but are spaced from each other so that the line-of-sight path length from the antenna at which they are beamed differs by approximately an odd multiple of 1/2-wavelength at the operating frequency. This spacing arrangement insures that simultaneous serious fading at both antennas is extremely unlikely. Both receivers are tuned to the same frequency and receive the same signal. In this system, the signal-to-noise ratios of both receivers are constantly monitored and, by electronic control circuits, the receiver whose output provides the best signal-to-noise ratio at any moment is selected to furnish the video signal to be used.

b. Fading. The term fading, as used in connection with diversity reception, refers to variations (usually attenuation) of signal strength over periods ranging from a fraction of a second to a duration of several minutes. It does not, in this application, refer to the slow, hour-to-hour, day-to-night, day-to-day, or seasonal variations in signal strength. Signal fading is caused principally by the fact that radio waves propagated from a transmitting antenna may travel over two or more paths in reaching the receiving antenna. This is described in paragraph 40.

c. Elimination of Effects of Fading. The diversity system of reception practically eliminates the possibility of complete loss of received signals because the receiving antennas are positioned so that their distances from the transmitting antenna make it highly improbable that a secondary path signal will cancel the received signal at both antennas simultaneously. The signal induced in one antenna is usually greater than that induced in the other during fading. The receiver output signals are not combined; instead the best is selected and switched by relay contacts to the associated transmitter at a through repeater station, or to the multiplex equipment at a terminal or drop-channel repeater.

207. Diversity Circuit Interconnections

a. All of the circuits used for sampling, comparison, control, and switching functions for diversity operation are located in the order-wire receivers. Because the video output of each radio receiver is fed to its respective order-wire receiver, it is necessary to interconnect only the order-wire receivers. This interconnection is done with two cables (fig. 268) (part of a typical east-west diversity repeater station). One is a coaxial cable that connects the video output of one receiver to the switching circuits of the other receiver. The other, a multiconductor cable, is connected to DIVERSITY INTERCONN connector J8 on each order-wire receiver. It carries all of the other signals necessary for the proper functioning of the diversity circuits. This cable is not symmetrical; one end is connected and wired differently from the other end. This difference is necessary to achieve desired connections for diversity operation. One end of the cable is color coded red, and the order-wire receiver to which this end is connected is designated as the *preferred* unit.

b. To avoid confusion when dealing with two identical receivers, one is arbitrarily designated as the preferred receiver (receiver B) and the other as the standby receiver (receiver A). The essential difference between them functionally is that the preferred receiver is selected to monitor the control and switching functions for diversity operation. As a further distinction, mention of parts by reference designation in the standby receiver includes a prime (′) symbol following the reference designation; for example, J8′ in the standby receiver corresponds to J8 in the preferred receiver.

c. The microwave signal is picked up by both antennas. The signal from antenna 1 passes through the duplexer and is connected to the

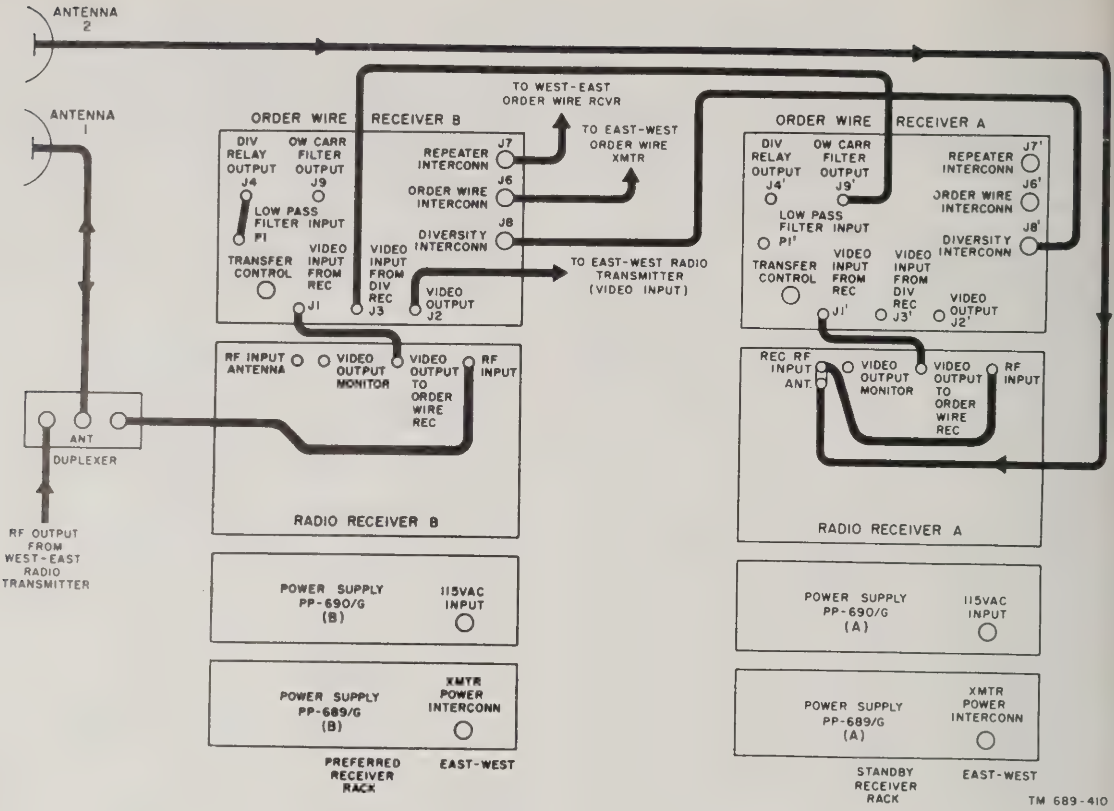

ANTENNA 2
ANTENNA 1
ORDER WIRE RECEIVER B
DIV RELAY OUTPUT J4
OW CARR FILTER OUTPUT J9
LOW PASS FILTER INPUT P1
TRANSFER CONTROL
VIDEO INPUT FROM REC J1
VIDEO INPUT FROM DIV REC J3
VIDEO OUTPUT J2
REPEATER INTERCONN J7
ORDER WIRE INTERCONN J6
DIVERSITY INTERCONN J8
TO WEST-EAST ORDER WIRE RCVR
TO EAST-WEST ORDER WIRE XMTR
TO EAST-WEST RADIO TRANSMITTER (VIDEO INPUT)
ORDER WIRE RECEIVER A
DIV RELAY OUTPUT J4'
OW CARR FILTER OUTPUT J9'
LOW PASS FILTER INPUT P1'
TRANSFER CONTROL
VIDEO INPUT FROM REC J1'
VIDEO INPUT FROM DIV REC J3'
VIDEO OUTPUT J2'
REPEATER INTERCONN J7'
ORDER WIRE INTERCONN J6'
DIVERSITY INTERCONN J8'
RF INPUT ANTENNA
VIDEO OUTPUT MONITOR
VIDEO OUTPUT TO ORDER WIRE REC
RF INPUT
RADIO RECEIVER B
REC RF INPUT ANT.
VIDEO OUTPUT MONITOR
VIDEO OUTPUT TO ORDER WIRE REC
RF INPUT
RADIO RECEIVER A
ANT
DUPLEXER
RF OUTPUT FROM WEST-EAST RADIO TRANSMITTER
POWER SUPPLY PP-690/G (B)
115VAC INPUT
POWER SUPPLY PP-689/G (B)
XMTR POWER INTERCONN
PREFERRED RECEIVER RACK
EAST-WEST
POWER SUPPLY PP-690/G (A)
115VAC INPUT
POWER SUPPLY PP-689/G (A)
XMTR POWER INTERCONN
STANDBY RECEIVER RACK
EAST-WEST
TM 689-410

Figure 268. Diversity cable interconnections at typical east-west repeater station.

antenna input of the preferred receiver. The signal from antenna 2 is applied to the antenna input of the standby receiver. The video output of each receiver is applied to its respective order-wire receiver at VIDEO INPUT FROM REC connector J1 (and J1′). The signal from the standby receiver is connected from J9′, the OW CARR FILTER OUTPUT connector on the standby order-wire receiver, to J3, the VIDEO INPUT FROM DIV REC connector on the preferred order-wire receiver. Connectors J1 and J3 feed the video outputs from both receivers to contacts on the diversity relay in the preferred order-wire receiver. The output of this relay appears at DIV RELAY OUTPUT connector J4 and is patched to LOW PASS FILTER INPUT connector P1. The filter output appears at VIDEO OUTPUT connector J2, which is connected to the video input of the east-west radio transmitter. The LOW PASS FILTER INPUT (P1′), VIDEO OUTPUT (J2′), VIDEO INPUT FROM DIV REC (J3′), DIV RELAY OUTPUT (J4′), ORDER WIRE INTERCONN (J6′), and REPEATER INTERCONN (J7′) connectors on the standby order-wire receiver are not used. Likewise, the OW CARR FILTER OUTPUT connector (J9) on the preferred order-wire receiver is not used.

208. Diversity Operating Characteristics

a. The diversity control and switching circuits operate within a signal-to-noise ratio range of 34 db to 12 db. As long as the signal-to-noise ratio of both receivers is better than 34 db, the output of the receiver that is operating is used, even though the signal-to-noise ratio of the other receiver may be better. If the signal-to-noise ratio of both receivers is worse than 8 to 12 db, the diversity system is disabled and the regular alarm operates. Within the signal-to-noise ratio range of 34 db to 12 db, the diversity switching and control circuits switch receivers as soon as the signal-to-noise ratio of the operating receiver becomes about 2 db relatively worse than that of the nonoperating receiver.

b. When both receiver outputs have the same signal-to-noise ratio (within 2 db), the video output of the receiver that was last supplying the signal is used for retransmission or demultiplexing. Assume that receiver B is operating and that both receivers have a signal-to-noise ratio of 34 db. Now assume that the signal-to-noise ratio of receiver B becomes worse and drops 2 db to 32 db; the signal-to-noise ratio of receiver A remains the same. The diversity circuits operate, and the video output of receiver A is switched to the input of the east-west transmitter; this replaces the output of receiver B. Now, if the signal-to-noise ratio of receiver A (the receiver now operating) should get worse and become the same as that of receiver B, no switching occurs. A curve indicating the ideal diversity characteristic is shown on figure 269. Regardless of which receiver is operating, its signal-to-noise ratio must become 2 db worse relative to that of the other receiver before switching occurs. At equal signal-to-noise ratios, there is no arbitrary preference for one receiver over another and the operating receiver remains operating.

c. Figure 270 shows a typical measured diversity characteristic curve. The diversity operating range extends from 34 db to 16 db, and the actual difference in signal-to-noise ratios required to cause switching varies from about 3 db when the receiver signal-to-noise ratios are about 30 db to less than 1 db when they are near 20 db.

d. A block diagram description of the diversity circuits is given in paragraph 209. Details of circuit operation, including sampling, switching, control and interlock, and the audio and ringing circuits, are contained in paragraphs 210 through 218.

209. Block Diagram Description

a. Diversity switching depends on changes in the relative signal-to-noise ratio of two signals; therefore, it is necessary to obtain voltages proportional to the signal-to-noise ratios; compare

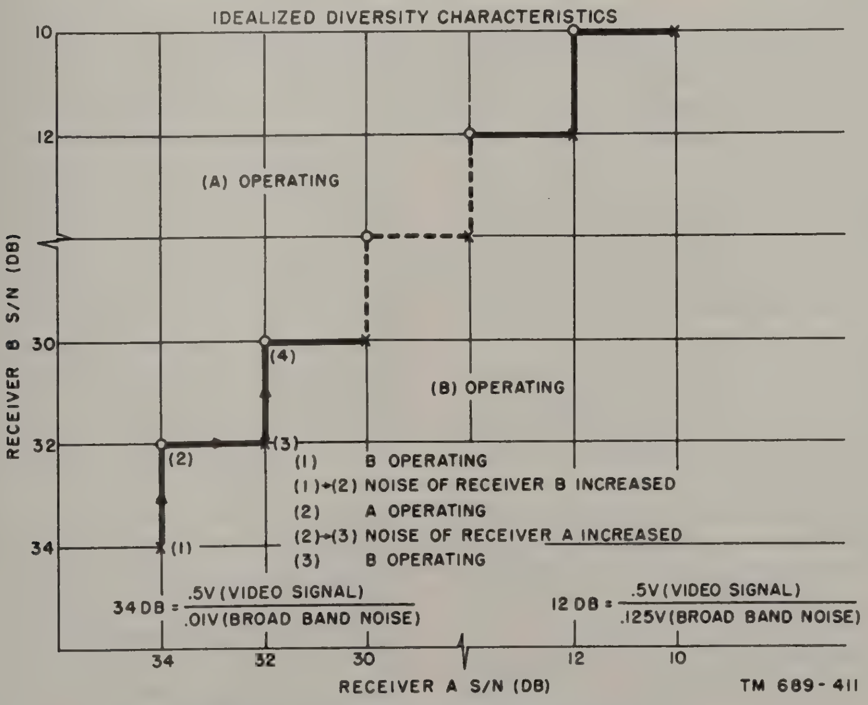


Figure 269. Ideal diversity characteristic curve.

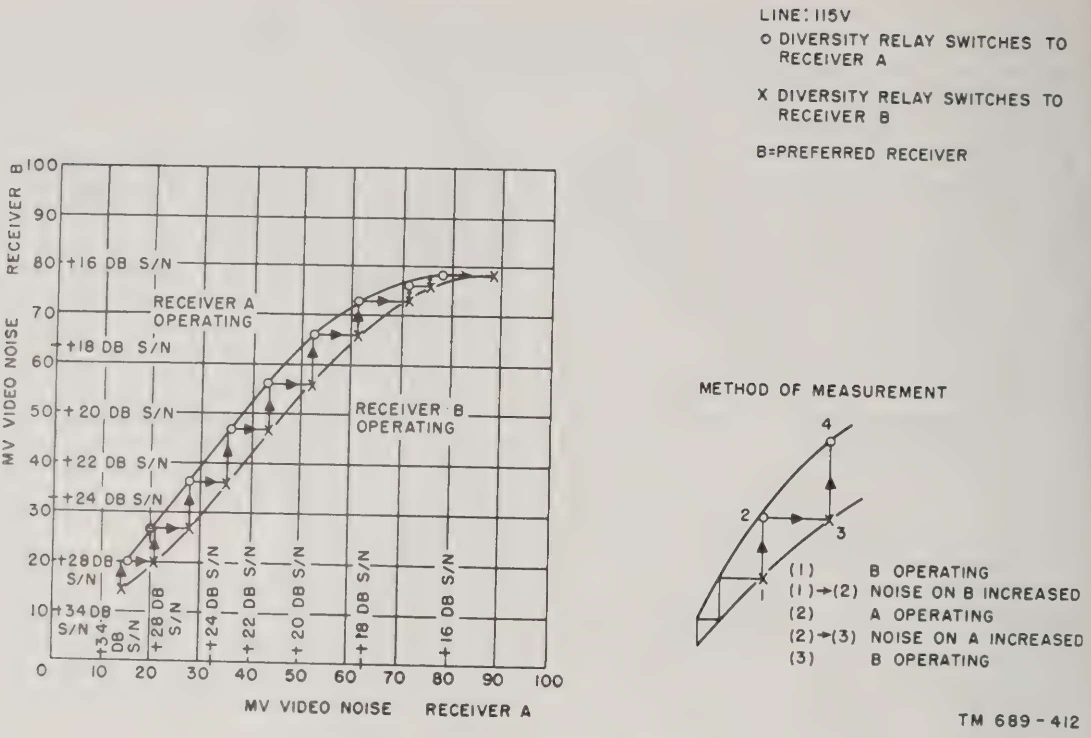


Figure 270. Typical measured diversity curve.

these voltages and, in turn, develop a difference voltage; this magnitude and sense can be used to control the switching circuits. If one of the two basic voltages (signal and noise) can be held constant, the variations of the other will be inversely proportional to the ratio between the two. Therefore, the signal voltage is held constant by the limiting action which takes place in the radio receiver. By monitoring the level of the noise voltage, a measure of the receiver signal-to-noise ratio can be obtained.

b. Such a voltage is obtained in the preferred receiver by sampling the ac component of the voltage at the screen grid of first limiter V3 (fig. 271). This contains components of broadband noise from 5.9 to 6.1 mc. The noise voltage is amplified by diversity noise amplifier V8B, the output of which is passed through a bandpass filter that transmits only components from 40 kc to 70 kc. The filter output is rectified by CR3 and appears across DIVERSITY CALIBRATE potentiometer R50 as a dc voltage proportional to the noise. A portion of this voltage is fed to one-half of diversity differential amplifier V9B′ which is in the standby order-wire receiver.

c. The other half of diversity differential amplifier V9B is located in the preferred orderwire receiver. It is fed with a voltage from DIVERSITY CALIBRATE potentiometer R50′ in the standby order-wire receiver. This signal is obtained as described above for the preferred order-wire receiver signal. The operation of V9B and V9B′, which together form the diversity differential amplifier, is exactly the same as that described in paragraph 187*b*(3) for the alarm differential amplifier.

d. The output of the differential amplifier feeds diversity relay control tube V9A in the preferred unit. The coil of diversity control relay K1 is in the plate circuit of V9A. When the signal-to-noise ratio of the preferred receiver, within the diversity operating range, is approximately 2 db better than that of the standby receiver, V9A conducts, holding K1 energized. This permits the video from the preferred receiver to be selected as the video signal to be used. When the signal-to-noise ratio of the standby receiver is approximately 2 db better than that of the preferred receiver, the conduction of V9A drops and releases the relay, causing the video output to be taken from the standby receiver. The receiver video which is selected is passed through the low pass filter and appears at VIDEO OUTPUT connector J2 on the preferred order-wire receiver, and is sent on to the next radio transmitter or to the multiplex equipment.

210. Diversity Noise Sampling Circuit
(fig. 272)

a. The 6-mc components of broad-band noise are detected in first limiter V3 and are taken from its screen grid as a signal 200-kc wide between 5.9 and 6.1 mc. They are connected through capacitor C37 to the grid of diversity noise amplifier V8B, one-half of a 2C51, where the voltage is developed across grid resistor R52. The output appearing across plate-load resistor R51 is coupled to the diversity noise filter, which consists of C38, C36, and L6. Only noise components in the band between 40 kc and 70 kc are passed by the filter. This provides a noise-voltage indication independent of carrier modulation.

b. Crystal rectifier CR3 converts the noise components to a negative voltage that varies in proportion to the radio receiver noise level. Capacitor C49 bypasses any 6-mc signal that may reach this point so that it will not be rectified by CR3. DIVERSITY CALIBRATE control R50 acts as the detector load. The variable control is necessary in both order-wire receivers to adjust the dc level applied to the grids of the

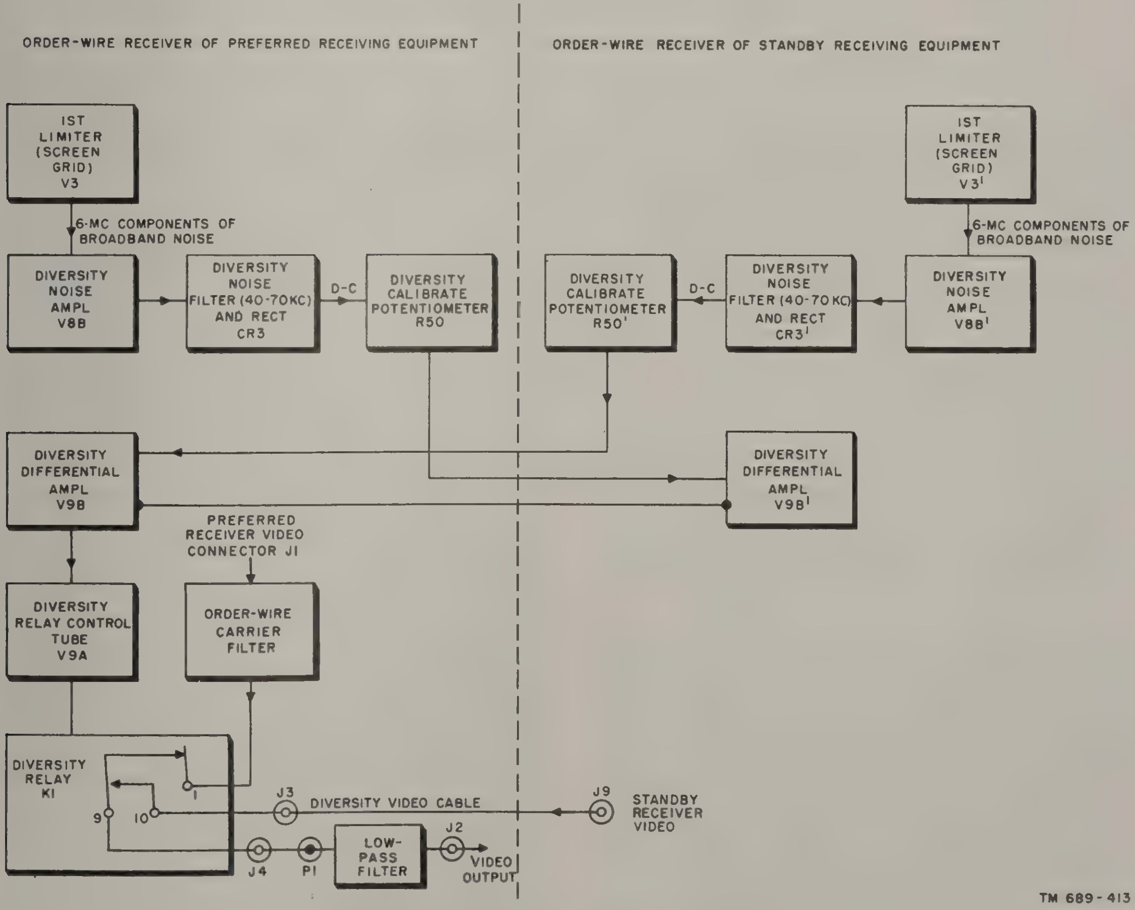
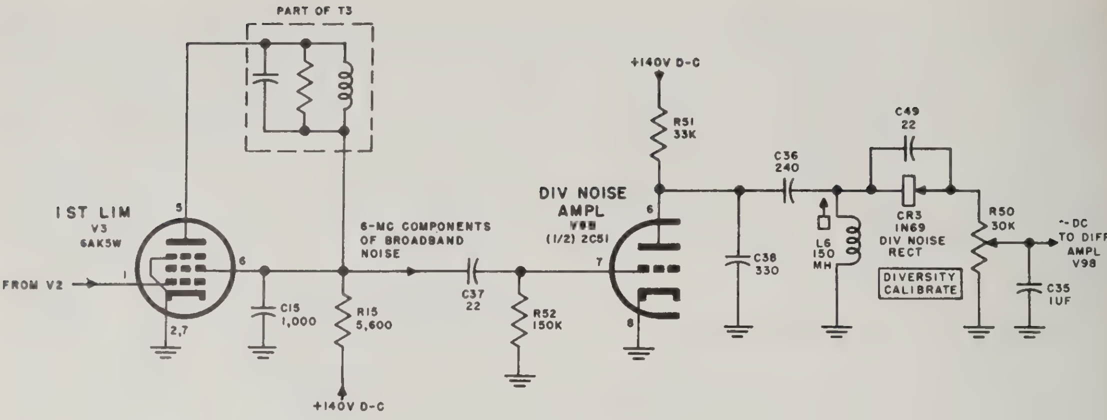

ORDER-WIRE RECEIVER OF PREFERRED RECEIVING EQUIPMENT
ORDER-WIRE RECEIVER OF STANDBY RECEIVING EQUIPMENT
IST LIMITER (SCREEN GRID) V3
6-MC COMPONENTS OF BROADBAND NOISE
DIVERSITY NOISE AMPL V8B
DIVERSITY NOISE FILTER (40-70KC) AND RECT CR3
D-C
DIVERSITY CALIBRATE POTENTIOMETER R50
DIVERSITY CALIBRATE POTENTIOMETER R50'
D-C
DIVERSITY NOISE FILTER (40-70 KC) AND RECT CR3'
DIVERSITY NOISE AMPL V8B'
IST LIMITER (SCREEN GRID) V3'
6-MC COMPONENTS OF BROADBAND NOISE
DIVERSITY DIFFERENTIAL AMPL V9B
DIVERSITY DIFFERENTIAL AMPL V9B'
PREFERRED RECEIVER VIDEO CONNECTOR J1
DIVERSITY RELAY CONTROL TUBE V9A
ORDER-WIRE CARRIER FILTER
DIVERSITY RELAY K1
1
9
10
J3
DIVERSITY VIDEO CABLE
J9
STANDBY RECEIVER VIDEO
J4
P1
LOW-PASS FILTER
J2
VIDEO OUTPUT
TM 689-413

Figure 271. Diversity circuits, block diagram.



NOTE:
UNLESS OTHERWISE SHOWN
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UUF

TM689-414

Figure 272. Diversity noise sampling circuit, simplified schematic diagram.

differential amplifier to compensate for inherent gain differences between units. In this way the same level of 6-mc noise results in equal dc voltages to the differential amplifier grids, regardless of variations in circuit parameters or rectifier efficiency. Capacitor C35 bypasses any remaining ac noise components and, because of its filtering action, prevents spurious switching from transients of the video output from one receiver to another.

c. Identical circuitry in the standby order-wire receiver, making use of V3′, V8B′, CR3′, and their associated parts, develops a similar dc voltage across R50′ proportional to the noise voltage in the standby radio receiver.

211. Diversity Differential Amplifier Circuit
(fig. 273)

a. To compare the broad-band noise levels of both radio receivers, the negative dc voltages representing noise levels are applied to the grids of a differential amplifier. The differential amplifier has two sections, which are physically separated. Tube V9B, one-half of a tube 2C51, is located in the preferred order-wire receiver and V9B′ is located in the standby order-wire receiver. When properly interconnected by the DIVERSITY INTERCONN cable, they form a differential amplifier, the parameters of which (except for the value of the output load) are identical with those of alarm differential amplifier V7 in each order-wire receiver (par. 187*b*).

b. The dc noise voltage from R50′ in the standby order-wire receiver is applied to the grid of V9B in the preferred order-wire receiver, and the dc noise voltage from R50 in the preferred order-wire receiver is applied to the grid of V9B′ in the standby order-wire receiver. The circuits are arranged so that the plate voltage of V9B′ is held at a relatively fixed level by R84 and R85, while the output voltage of the differential amplifier is taken at the plate of V9B, across plate load R59. Because the circuit is dc coupled, R50 in the noise rectifier output circuit acts as the grid load for V9B′. The cathodes of the two triode sections are coupled together and share a common cathode resistor, the resultant of R60 and R60′ in parallel, and returned to the −108-volt supply. This negative voltage is used, in conjunction with the unusually high cathode resistor value, to obtain the desired differential amplifier action.

c. The circuit shows that a large (negative) signal voltage at the grid of V9B (relative to that at V9B′) will cause a maximum positive voltage at the plate of V9B′; a large (negative) signal voltage at the grid of V9B′ (relative to

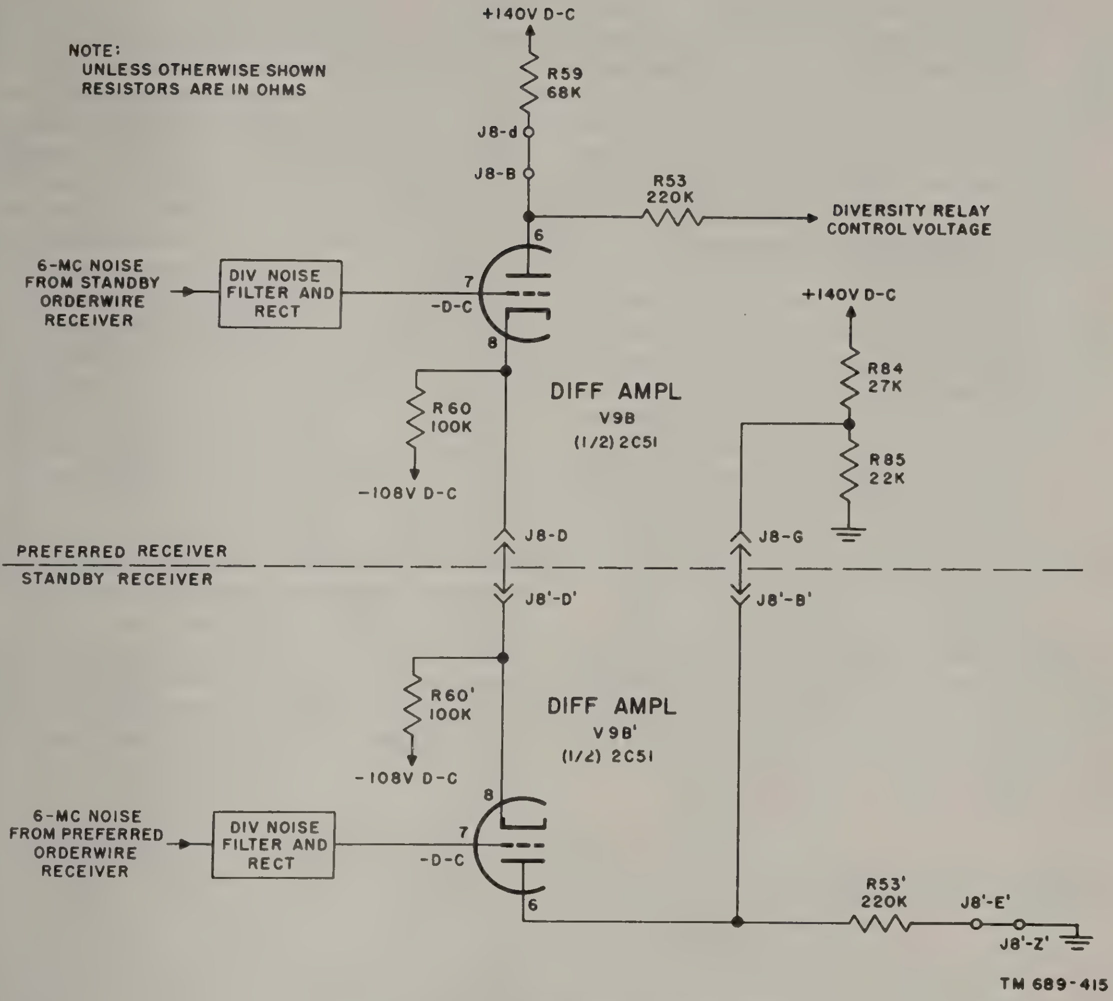

NOTE:
UNLESS OTHERWISE SHOWN
RESISTORS ARE IN OHMS
+140V D-C
R59
68K
J8-d
J8-B
R53
220K
DIVERSITY RELAY
CONTROL VOLTAGE
6
6-MC NOISE
FROM STANDBY
ORDERWIRE
RECEIVER
DIV NOISE
FILTER AND
RECT
7
-D-C
8
+140V D-C
R84
27K
DIFF AMPL
V9B
(1/2) 2C51
R60
100K
R85
22K
-108V D-C
J8-D
J8-G
PREFERRED RECEIVER
STANDBY RECEIVER
J8'-D'
J8'-B'
R60'
100K
DIFF AMPL
V9B'
(1/2) 2C51
-108V D-C
8
6-MC NOISE
FROM PREFERRED
ORDERWIRE
RECEIVER
DIV NOISE
FILTER AND
RECT
7
-D-C
6
R53'
220K
J8'-E'
J8'-Z'
TM 689-415

Figure 273. Diversity differential amplifier circuit, simplified schematic diagram.

that at V9B) will cause a minimum positive voltage at the plate of V9B. A maximum positive output voltage at the plate of V9B is needed when the signal-to-noise ratio of the standby receiver is worse than that of the preferred receiver; that is, the dc noise voltage from the standby receiver is more negative. Thus, the dc noise voltage from the standby receiver is fed to the differential amplifier section in the preferred unit, and vice versa. The operation of the V9A relay control tube is described and explained more fully in paragraph 212.

d. Consider the operation of the differential amplifier under the following three sets of conditions:

(1) The broad-band noise levels of both receivers are identical. The negative potentials at both differential amplifier grids are the same and move in synchronism with each other. The grid voltage and cathode voltage of V9B rise and fall together; this keeps the resultant bias on the tube essentially constant, which causes no significant change in V9B output voltage.

(2) The broad-band noise level of the preferred receiver is greater than that of the standby receiver. A larger negative dc voltage is applied to the grid of V9B′ than is applied to the grid of

V9B. Less current flows through V9B′, which causes the voltage at both cathodes (since they are tied together) to become less positive (or more negative). Although the grid voltage at V9B remains the same, there is less bias on V9B′, more current flows through it and causes the output voltage at its place to be lowered.

(3) The broad-band noise level of the stand-by receiver is greater than that of the preferred receiver. The conduction of V9B′ increases and raises the cathode voltage. The grid voltage at V9B remains the same while the bias on V9B is increased, and V9B goes toward cutoff, which raises the output voltage at its plate toward the maximum positive value.

212. Diversity Relay Control Tube Circuit
(fig. 274)

a. The output voltage at the plate of V9B is applied to one end of a voltage divider composed of R53, R54, and R56. The other end of the voltage divider is connected to the —109-volt dc supply. A portion of this voltage is tapped off at the arm of DIVERSITY PREFERENCE potentiometer R54, which is part of the divider. This is fed to the grid of diversity relay control tube V9A. The potentiometer is adjusted so that, when the output from V9B is near maximum, V9A will conduct heavily, and when the output from V9B is near minimum, V9A will conduct only slightly or will be completely cut off. When V9A is conducting heavily, diversity relay K1 in its plate circuit is operated. When V9A is almost or completely cut off, relay K1 is released. DIVERSITY PREFERENCE potentiometer R54 is adjusted to set the operating level of V9A so that in its quiescent state (zero excitation) the current flow through the tube is midway between the operate and release current points of relay K1.

b. A pair of transfer contacts on the diversity relays (K1 and K1′) is used for controlling the order-wire audio circuits. To obtain proper switching conditions for these circuits, when K1 operates, K1′ must simultaneously release; when K1 releases, K1′ must simultaneously operate. These switching requirements are shown in figure 274. When V9A is conducting and K1

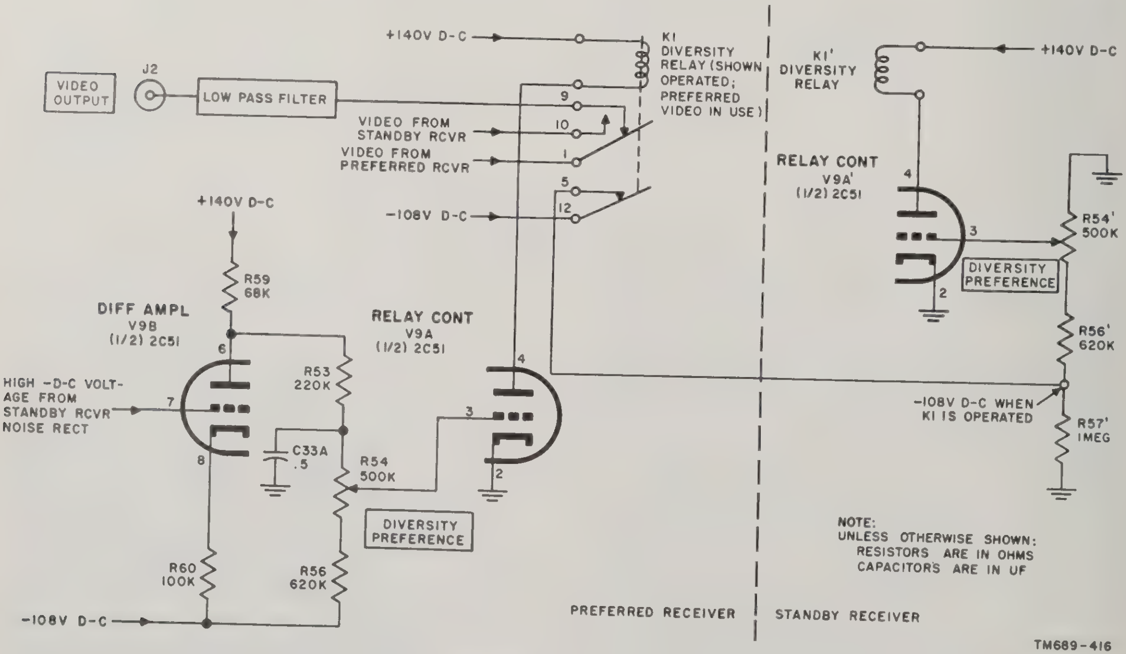

+140V D-C
K1
DIVERSITY
RELAY (SHOWN
OPERATED;
PREFERRED
VIDEO IN USE)
K1'
DIVERSITY
RELAY
+140V D-C
VIDEO
OUTPUT
J2
LOW PASS FILTER
9
10
1
5
12
VIDEO FROM
STANDBY RCVR
VIDEO FROM
PREFERRED RCVR
-108V D-C
+140V D-C
RELAY CONT
V9A'
(1/2) 2C51
4
3
2
R54'
500K
DIVERSITY
PREFERENCE
R56'
620K
-108V D-C WHEN
K1 IS OPERATED
R57'
1MEG
R59
68K
DIFF AMPL
V9B
(1/2) 2C51
6
7
8
HIGH -D-C VOLTAGE FROM
STANDBY RCVR
NOISE RECT
R53
220K
C33A
.5
R54
500K
DIVERSITY
PREFERENCE
RELAY CONT
V9A
(1/2) 2C51
4
3
2
R60
100K
R56
620K
-108V D-C
PREFERRED RECEIVER
STANDBY RECEIVER
NOTE:
UNLESS OTHERWISE SHOWN:
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UF
TM689-416

Figure 274. Diversity relay control tube circuits, simplified schematic diagram.

is operated, —108 volts dc is passed through contacts 12 and 5 to the junction of R56′ and R57′ in the standby unit. The upper end of R54′ is grounded, and sufficiently high negative voltage is applied to the grid of V9A′ to cut the tube off and release K1′. When V9A is cut off and K1 is released, the —108-volt dc connection is removed from the junction of R56′ and R57′. Resistor R57′, the lower end of which is grounded, is placed in the circuit and, since both ends of the V9A′ grid voltage divider now are grounded, the tube grid also is effectively grounded, the tube conducts heavily, and relay K1′ is operated.

213. Diversity Video Switching
(fig. 275)

a. The external video interconnections between the preferred and standby order-wire receivers have been described in paragraph 207 and shown on figure 268. Internal circuitry handling described in *b* below covers the video signals and shows how their switching is controlled by operation of the diversity relay.

b. The video signal from the preferred radio receiver enters the preferred order-wire receiver at J1 and arrives at the 6-mc trap. Here the 6-mc order-wire signal is separated from the main-channel video and passes through the shunt leg of the trap to the carrier amplifiers, where part of it is later used to indicate receiver noise level. The main-channel video information goes through the series leg of the trap (L3 and C4) and is connected to terminal 1 of diversity relay K1. A similar route is followed in the standby order-wire receiver by the video from the standby radio receiver, as far as the output of the series leg of the 6-mc trap. The video then is connected to J9′; from here it is carried in the diversity video cable to J3 on the preferred order-wire receiver. This connector is internally connected to terminal 10 of diversity relay K1.

c. Terminal 9, the output of K1, is connected to J4 which is patched to P1, the input to the low pass filter. The output of the low pass filter appears at J2 and from this point is cabled to the east-west radio transmitter. The low pass filter and the video contacts of the diversity relay in the standby order-wire receiver are not used.

d. In order to eliminate completely any momentary video-signal interruption due to switching, the video contacts on the diversity relay (fig. 275) are of the make-before-break type. By feeding from a low source impedance (the receiver video amplifier) into a higher-than-line-impedance load, the switching transient is reduced to less than 0.5 db. The impedance mismatch effect on the sampled 6-mc noise is reduced to a negligible value by the 6-mc antiresonant circuit (L3 and C4). Because the standby receiver output is working out of an impedance of approximately 15 ohms, through the 50-ohm cable into an impedance of about 83 ohms, it is not terminated. However, a cable length (from J9′ to J3) of 5 feet can be tolerated without noticeable deterioration of the video frequency response.

e. Examination of the circuit indicates the following:

(1) The position of K1′ has no effect on the video signal.

(2) When K1 is operated, video from the preferred receiver is fed through the low pass filter to the east-west radio transmitter.

(3) When K1 is released, video from the standby receiver is fed through the low pass filter to the east-west radio transmitter.

214. Diversity Control Circuit Interconnection Details
(fig. 276)

a. The circuits for controlling and switching the video signals in diversity operation are described in paragraphs 210 through 213 and on figures 272 through 275. Figure 276 shows the cross-connections effected by connection of the DIVERSITY INTERCONN cable between the preferred order-wire receiver and the standby order-wire receiver. The diversity equipment and circuity in both order-wire receivers are identical; but the cross-connections are necessary, because different functions are required from each when they are connected as the preferred and standby receivers in diversity operation. All these changes in circuitry are accomplished automatically when the DIVERSITY INTERCONN cable is connected between J8 in the preferred order-wire receiver and J8′ in the standby order-wire receiver. The wiring to the connectors in the cable at the two

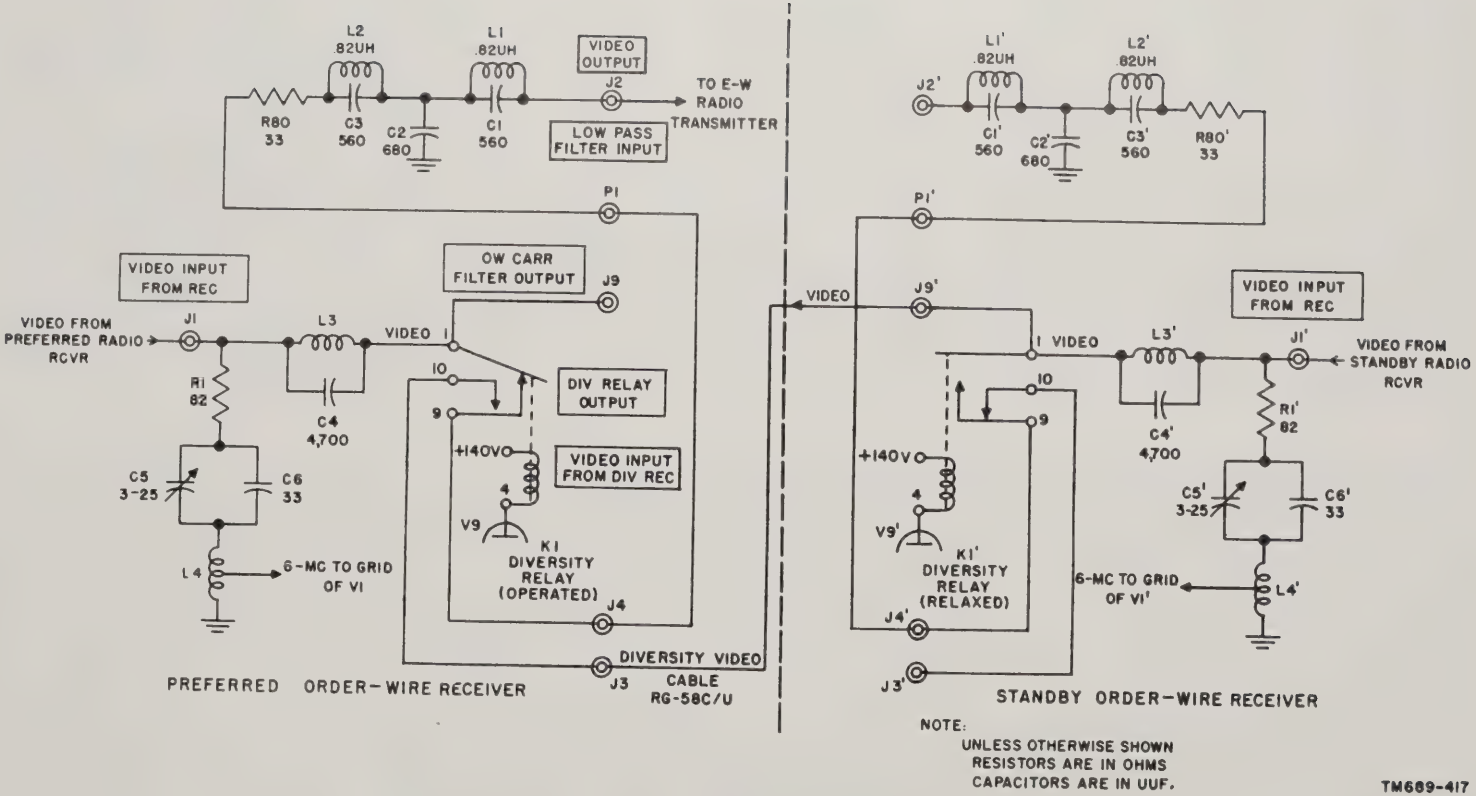

L2
.82UH
R80
33
C3
560
C2
680
L1
.82UH
C1
560
VIDEO
OUTPUT
J2
TO E-W
RADIO
TRANSMITTER
LOW PASS
FILTER INPUT
P1
VIDEO INPUT
FROM REC
VIDEO FROM
PREFERRED RADIO
RCVR
J1
L3
VIDEO
1
OW CARR
FILTER OUTPUT
J9
10
9
DIV RELAY
OUTPUT
R1
82
C4
4,700
+140V
VIDEO INPUT
FROM DIV REC
4
C5
3-25
C6
33
V9
K1
DIVERSITY
RELAY
(OPERATED)
L4
6-MC TO GRID
OF V1
J4
DIVERSITY VIDEO
CABLE
RG-58C/U
J3
PREFERRED ORDER-WIRE RECEIVER
L1'
.82UH
L2'
.82UH
J2'
C1'
560
C2'
680
C3'
560
R80'
33
P1'
VIDEO
J9'
VIDEO INPUT
FROM REC
1 VIDEO
L3'
J1'
VIDEO FROM
STANDBY RADIO
RCVR
10
9
+140V
4
V9'
C4'
4,700
R1'
82
C5'
3-25
C6'
33
K1'
DIVERSITY
RELAY
(RELAXED)
6-MC TO GRID
OF V1'
L4'
J4'
J3'
STANDBY ORDER-WIRE RECEIVER
NOTE:
UNLESS OTHERWISE SHOWN
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UUF.
TM689-417

Figure 275. Diversity video switching circuits, simplified schematic diagram.

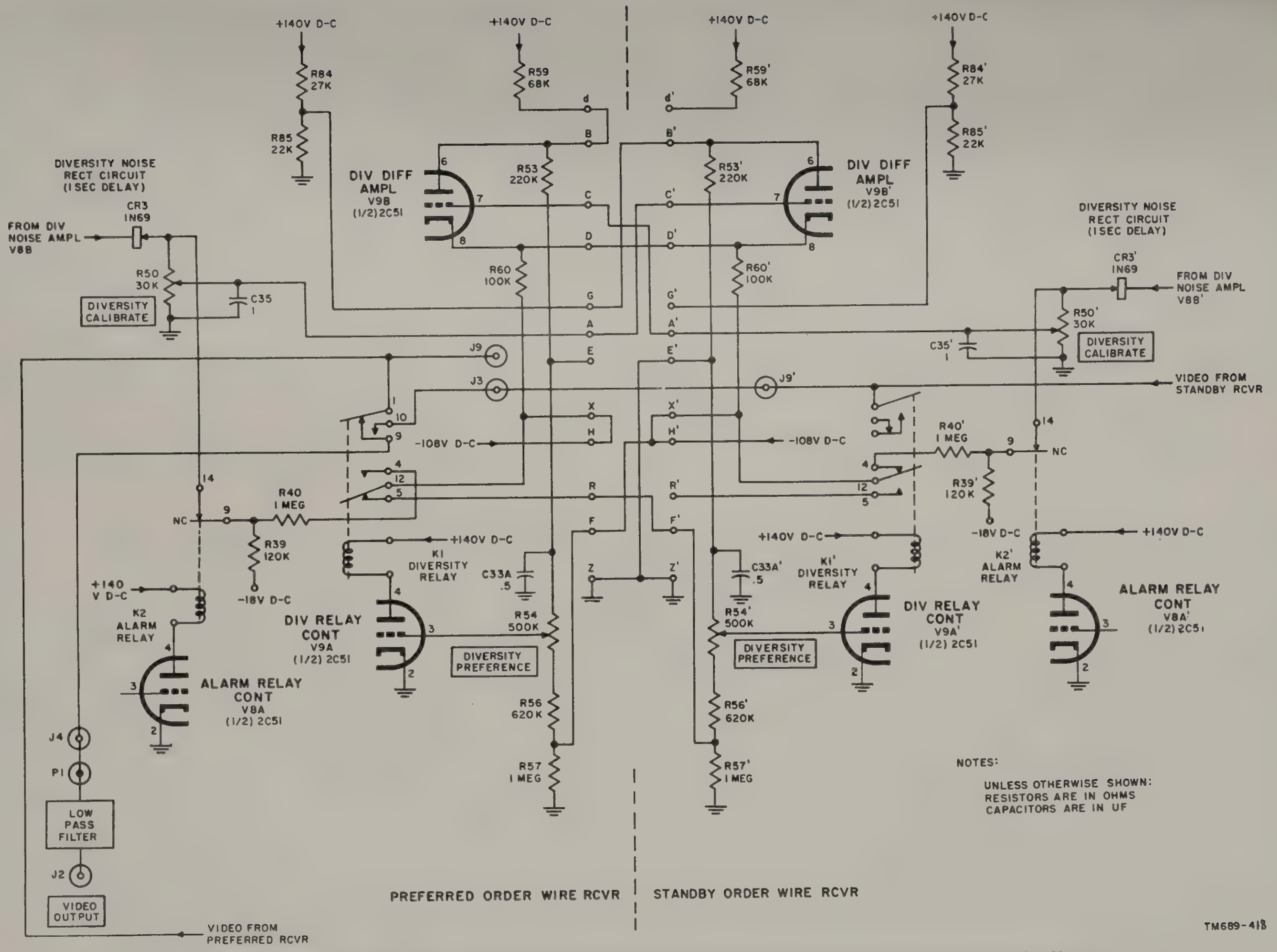

+140V D-C
R84 27K
R85 22K
R59 68K
d
B
C
D
G
A
E
X
H
R
F
Z
d'
B'
C'
D'
G'
A'
E'
X'
H'
R'
F'
Z'
R84' 27K
R85' 22K
R59' 68K
DIV DIFF AMPL V9B (1/2) 2C51
DIV DIFF AMPL V9B' (1/2) 2C51
R53 220K
R53' 220K
R60 100K
R60' 100K
DIVERSITY NOISE RECT CIRCUIT (1 SEC DELAY)
FROM DIV NOISE AMPL V8B
FROM DIV NOISE AMPL V8B'
CR3 1N69
CR3' 1N69
R50 30K
R50' 30K
DIVERSITY CALIBRATE
C35 1
C35' 1
J9
J3
J9'
VIDEO FROM STANDBY RCVR
-108V D-C
R40 1 MEG
R40' 1 MEG
R39 120K
R39' 120K
-18V D-C
NC
14
9
K1 DIVERSITY RELAY
K1' DIVERSITY RELAY
K2 ALARM RELAY
K2' ALARM RELAY
+140 V D-C
C33A .5
C33A' .5
R54 500K
R54' 500K
DIVERSITY PREFERENCE
DIV RELAY CONT V9A (1/2) 2C51
DIV RELAY CONT V9A' (1/2) 2C51
ALARM RELAY CONT V8A (1/2) 2C51
ALARM RELAY CONT V8A' (1/2) 2C51
R56 620K
R56' 620K
R57 1 MEG
R57' 1 MEG
J4
P1
LOW PASS FILTER
J2
VIDEO OUTPUT
VIDEO FROM PREFERRED RCVR
PREFERRED ORDER WIRE RCVR
STANDBY ORDER WIRE RCVR
NOTES:
UNLESS OTHERWISE SHOWN:
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UF
TM689-418

Figure 276. Diversity cable cross-connection; diversity alarm interlock circuits, simplified schematic diagram.

ends is not the same. To insure proper orientation of the cable, the connector which is to be attached to J8 in the preferred receiver is color-coded red.

b. The dc diversity noise voltage from the standby receiver is connected from the arm of R50′ in the standby unit through A′ in J8′, through C in J8, to the grid of V9B, one-half of the differential amplifier, in the preferred unit. Jumper B–D in J8 connects the plate of V9B to plate-load resistor R59. Lead D–D′ in the cable interconnects the cathodes of the two halves of the differential amplifier. The dc diversity noise voltage from the preferred receiver is connected from the arm of R50 through A (J8), through C′ (J8′), to the grid of V9B′, the other half of the differential amplifier, in the standby unit. Lead B′–G in the cable connects the V9B′ plate with its plate voltage supply, R84 and R85, in the preferred unit.

c. Jumpers H–X (J8) and H′–X′ (J8′) connect the —108-volt supply to R60 and R60′, the V9B and V9B′ differential amplifier cathode resistors. Cable lead H′–F connects —108 volts from the standby unit to the junction of R56 and R57 in relay control tube V9A input circuit in the preferred unit. The —108 volts dc is connected through the H–X jumper in J8 to terminal 12 of diversity relay K1. When K1 is operated, this voltage is connected to terminal 5 of K1, and from there goes through R (J8), through F′ (J8′), to the junction of R56′ and R57′ in the standby unit. This voltage is applied only when K1 is operated. At other times, the ground connection at the lower end of R57′ is effective. The upper end of this divider, R54′, R56′, and R57′, which forms the input circuit for relay control tube V9A′, is grounded through E′ and a jumper in J8′ to grounded pin Z′.

d. The video from the standby receiver is connected, by means of a separate coaxial cable, from J9′ in the standby receiver to J3 in the preferred receiver, and from there to terminal 10 of diversity relay K1.

215. Diversity Alarm Interlock and Lockup Circuits

(fig. 276)

a. Alarm Interlock Circuit.

(1) Because the principle of diversity switching is based on the use of the receiver exhibiting the lowest amount of broad-band noise, a problem would arise if the video signal in one of the receivers disappeared completely (due to a cable short, video amplifier failure, or other cause). If this occurs, the 6-mc subcarrier signal would disappear also and exhibit a condition of zero noise in the diversity noise sampling circuit for that receiver. This would result in the receiver appearing to the diversity circuits as the one with the better signal-to-noise ratio, and the diversity relay would attempt to take the video output from a defective unit. To prevent such a condition, the diversity circuits are interlocked with the alarm circuits in the order-wire receivers; this takes advantage of the fact that the alarm circuits operate immediately upon failure of the 6-mc subcarrier (par. 187). Loss of the 6-mc subcarrier causes immediate disabling of the diversity circuitry.

(2) If the video and 6-mc subcarrier in the preferred receiver fail, alarm relay control tube V8A is cut off, alarm relay K2 releases. Contacts 9 and 14 on K2 close, which applies —18 volts dc through R39 and the relay contacts to the ungrounded end of DIVERSITY CALIBRATE potentiometer R50. This causes a negative voltage to appear at the arm of R50 far greater than that developed by any noise voltage. This voltage appears as high noise signal to the diversity circuits, K1 releases, and video output is taken from the standby receiver. This action occurs before normal diversity operation can take place, because of the 1-second time-delay inherent in the diversity noise filter and rectifier circuit. If the failure occurs in the standby receiver, —18 volts is applied to R50′, K1 is operated, and the video signal is taken from the preferred unit.

(3) Operation of the alarm circuit because of tube failure, etc., will automatically cause the diversity circuits to be disabled. Failure of the +140-volt supply or of tube V9 will cause K1 to re-

lease and switch operation to the standby receiver.

b. Alarm Lockup Circuit.

(1) To insure reliable operation of the diversity circuits in situations where the video and 6-mc subcarrier have failed in one receiver and, during the failure period, the 6-mc subcarrier in the other receiver is keyed off for ringing purposes (or if a sharp fade should occur in both receivers simultaneously), an additional control bias is added to the alarm interlock circuit described in *a* above. If this were not done, the video output would be switched to a nonoperating receiver during a ring interval in an operating receiver. This additional bias acts as a lockup circuit which allows the receiver that was last operating to continue operating when the 6-mc subcarrier fails in both receivers.

(2) Assume that the preferred receiver is operating when both 6-mc signals disappear. The circuit conditions are as shown in figure 276; relay K1′ is released. When the 6-mc signals fail, alarm relays K2 and K2′ release. Because relay K1 is operated, nothing occurs in the circuit of the preferred unit beyond the application of the —18-volt alarm interlock bias. Since K1′ is released, however, in addition to the —18-volt bias, —108-volts dc is applied through the H′–X′ jumper in J8′, through contacts 12 and 4 of K1′, through resistor R40′, through contacts 9 and 14 of relay K2′, to the ungrounded side of potentiometer R50′. The arm of R50′ applies a high negative potential to the grid of V9B in the preferred unit and, through the normal diversity circuitry, relay K1 is maintained in the operated condition. If K1 had been released when the failure condition occurred, the — 108 volts would have been applied through the preferred unit circuitry to the grid of V9B′, the opposite action would have taken place, and relay K1′ would have been maintained operated and K1 rereleased.

216. Diversity Incoming Ring and Alarm Control Circuit

(fig. 277)

a. The order-wire receiver buzzers and the remote handset bells must operate during an incoming ring signal and during a bona fide alarm condition. At the same time, it is undesirable and often confusing to the operator if spurious ringing occurs when there is a sharp fade or a failure in only one unit. Since all these conditions represent an absence of 6-mc signal, the receiver is unable to differentiate among them. To overcome this problem, the incoming ring circuits are arranged to operate only when the ring signal is detected simultaneously by both receivers (alarm relays K2 and K2′ release at same time). This is accomplished by connecting in series all alarm relay contacts involving the ring circuits.

b. When both alarm relays are released, 115-volt ac is connected, in the preferred order-wire receiver only, through fuse F1 to J8, through jumper S–U (J8), through contacts 12 and 4 (K2), through contacts 5 and 3 (S2) to J8; from V (J8) through the diversity interconnecting cable to U′ (J8′), through contacts 12 and 4 (K2′), and through contacts 5 and 3 (S2′) to J8′; through jumper V′–Y′ (J8′) directly to the buzzer in the standby unit; and through lead Y′–Y in the diversity cable to the buzzer in the preferred unit.

c. Under the same conditions, —18 volts dc for the remote handset bells is connected to P (J8), through jumper P–T (J8), through contacts 11 and 1 (K2), through contacts 6 and 4 (S2) to J8; from W (J8) through the diversity cable to T′ (J8′), through contacts 11 and 1 (K2′), through contacts 6 and 4 (S2′) to J8′; through jumper W′–J′ (J8′), directly to the bell in the standby unit remote handset; and through lead J′–J in the diversity cable to the bell in the preferred unit remote handset.

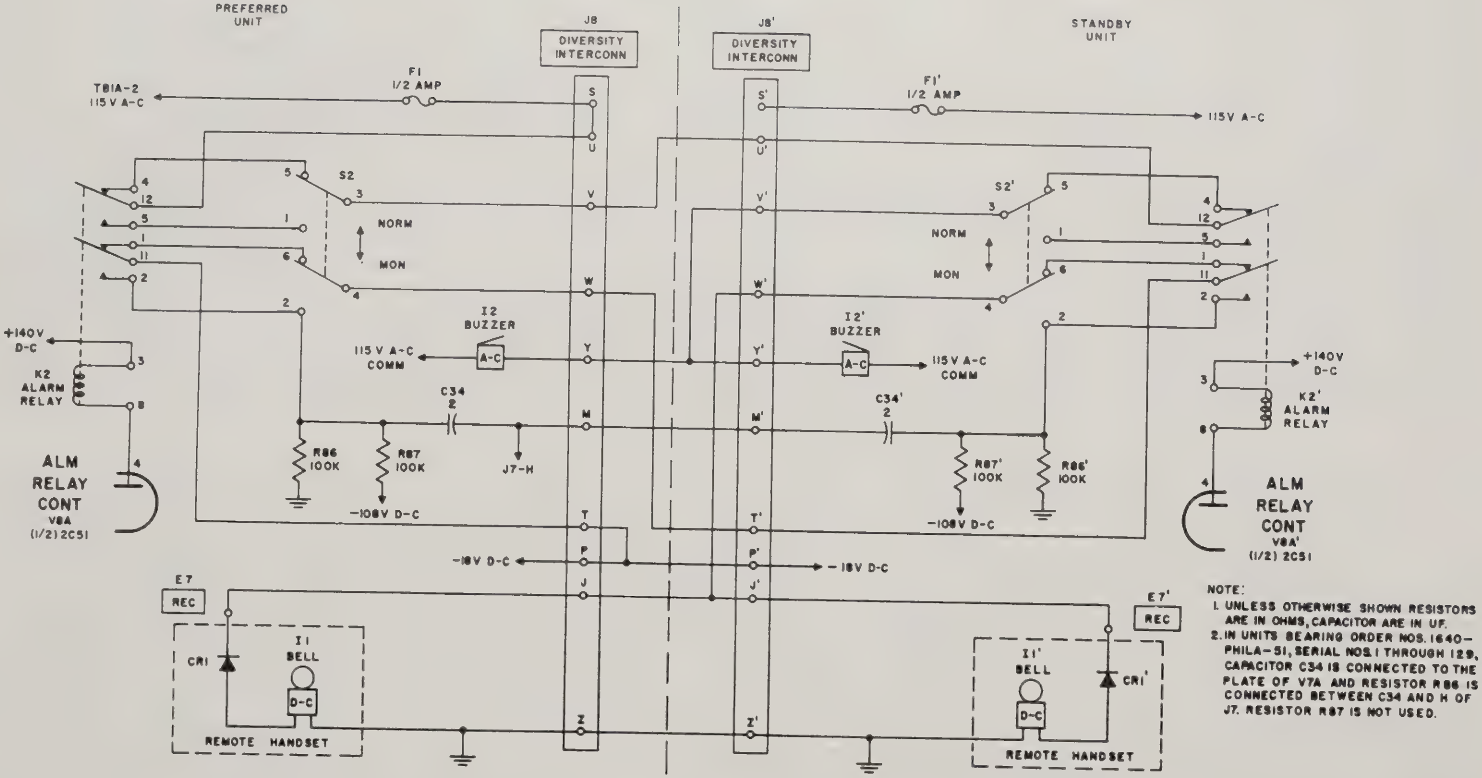
d. Because these conditions require both alarm relays to release simultaneously, proper diversity operation is maintained by the alarm lockup circuit described in paragraph 215*b*.

217. Diversity Through Local (Outgoing) Ring Connections

(fig. 278)

a. Through Ring.

(1) The operation of the normal through


PREFERRED UNIT
J8
DIVERSITY INTERCONN
J8'
DIVERSITY INTERCONN
STANDBY UNIT
TB1A-2
115 V A-C
F1
1/2 AMP
F1'
1/2 AMP
115V A-C
S
U
V
W
Y
M
T
P
J
Z
S'
U'
V'
W'
Y'
M'
T'
P'
J'
Z'
S2
S2'
NORM
MON
4
12
5
1
11
2
3
6
+140V D-C
K2 ALARM RELAY
K2' ALARM RELAY
8
I2 BUZZER
I2' BUZZER
A-C
115 V A-C COMM
C34 2
C34' 2
R86 100K
R87 100K
R86' 100K
R87' 100K
J7-H
-108V D-C
-18V D-C
ALM RELAY CONT V8A (1/2) 2C51
ALM RELAY CONT V8A' (1/2) 2C51
E7
REC
E7'
CR1
CR1'
I1 BELL
I1' BELL
D-C
REMOTE HANDSET

NOTE:
1. UNLESS OTHERWISE SHOWN RESISTORS ARE IN OHMS, CAPACITOR ARE IN UF.
2. IN UNITS BEARING ORDER NOS. 1640-PHILA-51, SERIAL NOS. 1 THROUGH 129, CAPACITOR C34 IS CONNECTED TO THE PLATE OF V7A AND RESISTOR R86 IS CONNECTED BETWEEN C34 AND H OF J7. RESISTOR R87 IS NOT USED.

TM689-419

Figure 277. Diversity incoming ring and alarm control, simplified schematic diagram.

ring (to the east-west order-wire transmitter) and repeater (to the west-east order-wire receiver) circuits are described in paragraph 186*d*(6) and shown on figure 248. Essential parts of this circuit, as they relate to diversity operation, are shown on figure 278.

(2) A through ring pulse received by the standby order-wire receiver is connected from alarm differential amplifier V7A′ in the standby order-wire receiver through C34′ and R86′ to M′ on J8′. It is carried through the diversity cable to M on J8 that is connected to H on J7. From this point, the signal follows the same path as that from the preferred order-wire receiver. To prevent reechoing, a through ring signal received by an east-west receiver is passed on only to the east-west transmitter; it is not connected to the west-east equipment.

b. Local Ring.

(1) Information on local ring operation is given in paragraph 186*d*(5) and shown on figure 247. Essential parts of this circuitry, as they relate to diversity operation, are shown on figure 278.

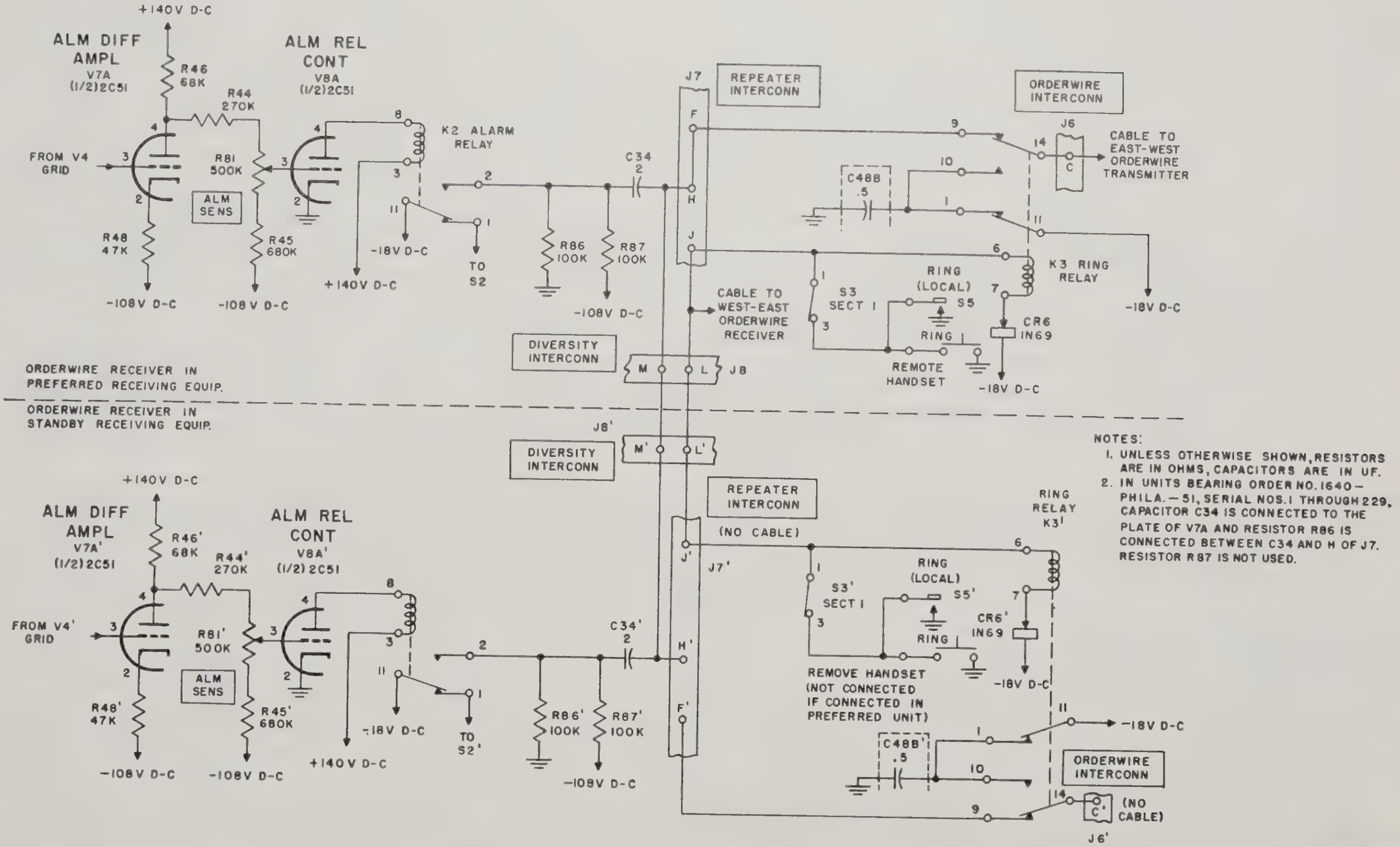
(2) A local ring signal, initiated by depressing S5 in the preferred order-wire receiver or the ring button in its remote handset, passes through contacts 3 and 1 of S3A and places ground on terminal 6 of ring relay K3. Ground is also furnished to the ring relay in the west-east order-wire receiver through J7 and the J lead of the REPEATER INTERCONN cable and causes ringing in both directions. In addition to this, the ground connection is connected to terminal L of J8, through the diversity cable to L′ of J8′, and from there to ring relay K3′ in the standby order-wire receiver. By the same interconnections, a ring signal initiated by S5′ in the standby order-wire receiver or by the ring button in its remote handset (if used) is sent back to the ring circuitry in the preferred order-wire receiver. This causes the same circuit actions as those which occur when the signal is initiated in the preferred order-wire receiver.

218. Diversity Audio Connections
(fig. 279)

a. For a maximum convenience and operating efficiency, handsets in both the preferred and standby order-wire receivers are connected at all times. Normally, since the two order-wire receivers contain identical internal circuitry, this would mean that both sets of audio amplifier circuits also would be operative simultaneously. If this situation were permitted to exist, the result would be double terminations in the audio circuits, with consequent excessive loading, as well as the possibility of noise from a failed receiver being superimposed on the desired audio signal. These undesirable conditions are prevented by circuitry which disables the audio circuits in one receiver during the period when its video output is not being used. Thus, only one set of audio circuits is operative at any one time. The circuits which accomplish this, together with the essentials of the associated normal audio circuits, are shown on figure 279. For more complete information on the audio connections from a single order-wire receiver, see figure 247.

b. Five leads in the diversity cable form the principal interconnections for these circuits between the preferred and standby receivers. Lead a–a′ (J8–J8′) carries the local audio incoming signal, lead K–K′ carries the through audio signal, lead N–N′ carries the local audio outgoing signal, lead J–J′ is used for the incoming through ring signal, and lead Z–Z′ is the common ground. Thus, common connections between the preferred and standby order-wire receivers for all audio functions, as well as those incoming through ring signals, are obtained.

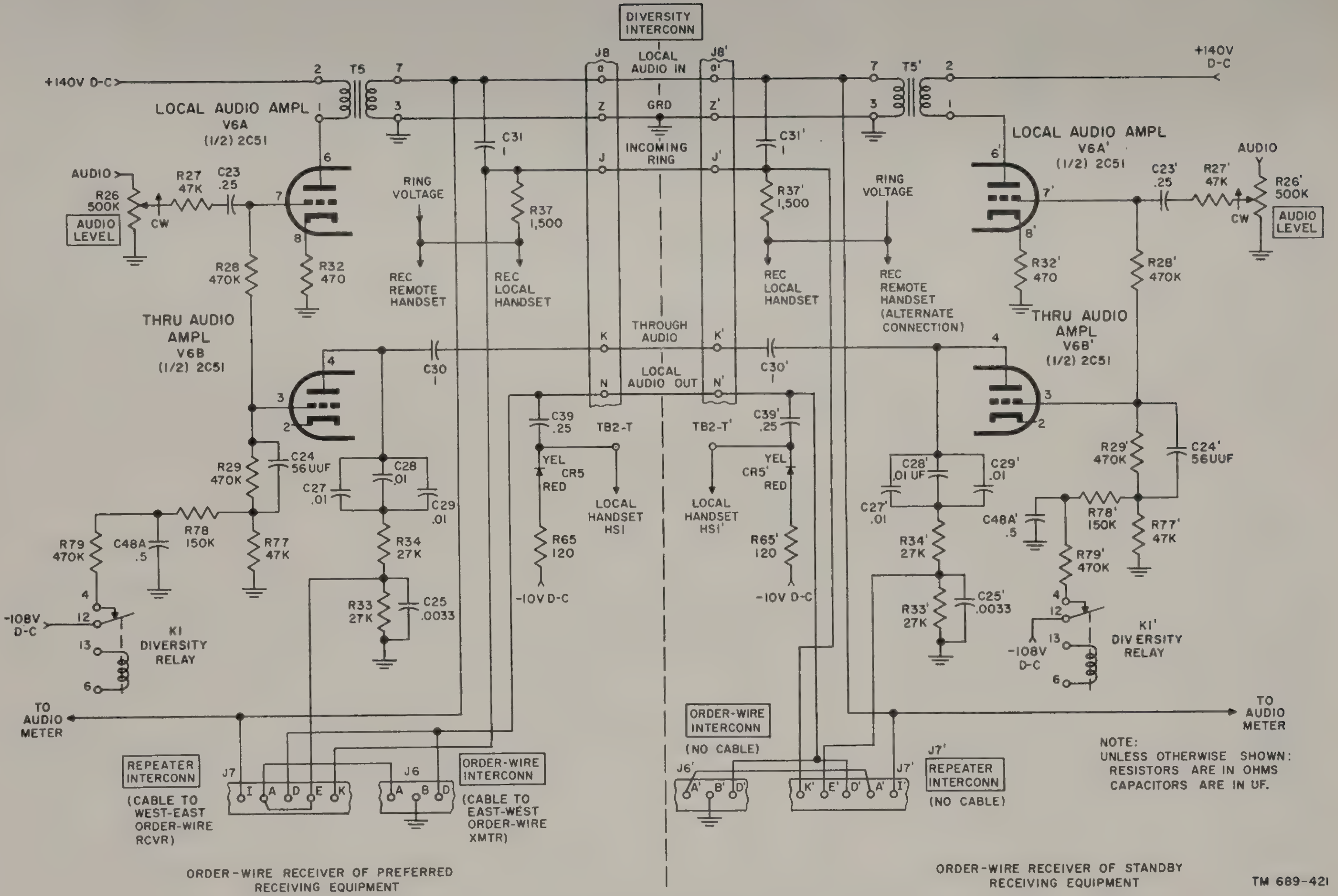
c. Figure 279 shows relay K1 in the preferred receiver in operated condition, so that the output of the preferred receiver is being used. Relay K1′ in the standby receiver is released, and —108-volt dc is applied through its contacts 12 and 4, through R79′, R78′, and R29′, to the grid of through audio amplifier V6B′, and through R28′ to the grid of local audio amplifier V6A′, providing a bias which cuts the tubes off. Audio output then is furnished only from V6B in the preferred order-wire receiver. When video is


+140V D-C
ALM DIFF AMPL V7A (1/2)2C51
R46 68K
R44 270K
ALM REL CONT V8A (1/2)2C51
FROM V4 GRID
R81 500K
ALM SENS
R48 47K
R45 680K
-108V D-C
-108 V D-C
+140V D-C
K2 ALARM RELAY
-18V D-C
TO S2
C34 2
R86 100K
R87 100K
-108V D-C
J7
REPEATER INTERCONN
F
H
J
ORDERWIRE INTERCONN
J6
C
CABLE TO EAST-WEST ORDERWIRE TRANSMITTER
C48B .5
K3 RING RELAY
-18V D-C
S3 SECT I
RING (LOCAL)
S5
RING
REMOTE HANDSET
CR6 IN69
-18V D-C
CABLE TO WEST-EAST ORDERWIRE RECEIVER
DIVERSITY INTERCONN
M
L
J8
ORDERWIRE RECEIVER IN PREFERRED RECEIVING EQUIP.
ORDERWIRE RECEIVER IN STANDBY RECEIVING EQUIP.
J8'
DIVERSITY INTERCONN
M'
L'
+140V D-C
ALM DIFF AMPL V7A' (1/2)2C51
R46' 68K
R44' 270K
ALM REL CONT V8A' (1/2)2C51
FROM V4' GRID
R81' 500K
ALM SENS
R48' 47K
R45' 680K
-108V D-C
-108V D-C
+140V D-C
-18V D-C
TO S2'
C34' 2
R86' 100K
R87' 100K
-108V D-C
REPEATER INTERCONN
(NO CABLE)
J'
J7'
H'
F'
RING RELAY K3'
S3' SECT I
RING (LOCAL)
S5'
RING
CR6' IN69
-18V D-C
REMOVE HANDSET (NOT CONNECTED IF CONNECTED IN PREFERRED UNIT)
C48B' .5
-18V D-C
ORDERWIRE INTERCONN
C'
(NO CABLE)
J6'

NOTES:
1. UNLESS OTHERWISE SHOWN, RESISTORS ARE IN OHMS, CAPACITORS ARE IN UF.
2. IN UNITS BEARING ORDER NO. 1640—PHILA.—51, SERIAL NOS. 1 THROUGH 229, CAPACITOR C34 IS CONNECTED TO THE PLATE OF V7A AND RESISTOR R86 IS CONNECTED BETWEEN C34 AND H OF J7. RESISTOR R87 IS NOT USED.

TM 689-420

Figure 278. Diversity through and local outgoing ring connections, simplified schematic diagram.


DIVERSITY INTERCONN
J8
J8'
LOCAL AUDIO IN
GRD
INCOMING RING
THROUGH AUDIO
LOCAL AUDIO OUT
+140V D-C
T5
T5'
LOCAL AUDIO AMPL V6A (1/2) 2C51
LOCAL AUDIO AMPL V6A' (1/2) 2C51
AUDIO
R26 500K
R26' 500K
AUDIO LEVEL
CW
R27 47K
R27' 47K
C23 .25
C23' .25
R28 470K
R28' 470K
R32 470
R32' 470
C31 1
C31' 1
R37 1,500
R37' 1,500
RING VOLTAGE
REC REMOTE HANDSET
REC LOCAL HANDSET
REC REMOTE HANDSET (ALTERNATE CONNECTION)
THRU AUDIO AMPL V6B (1/2) 2C51
THRU AUDIO AMPL V6B' (1/2) 2C51
C30 1
C30' 1
C24 56UUF
C24' 56UUF
R29 470K
R29' 470K
C28 .01
C28' .01 UF
C27 .01
C27' .01
C29 .01
C29' .01
R34 27K
R34' 27K
R33 27K
R33' 27K
C25 .0033
C25' .0033
R78 150K
R78' 150K
R77 47K
R77' 47K
R79 470K
R79' 470K
C48A .5
C48A' .5
-108V D-C
K1 DIVERSITY RELAY
K1' DIVERSITY RELAY
C39 .25
C39' .25
TB2-T
TB2-T'
YEL
CR5
CR5'
RED
LOCAL HANDSET HS1
LOCAL HANDSET HS1'
R65 120
R65' 120
-10V D-C
TO AUDIO METER
REPEATER INTERCONN
(CABLE TO WEST-EAST ORDER-WIRE RCVR)
J7
J6
ORDER-WIRE INTERCONN
(CABLE TO EAST-WEST ORDER-WIRE XMTR)
ORDER-WIRE INTERCONN
(NO CABLE)
J6'
J7'
REPEATER INTERCONN
(NO CABLE)
ORDER-WIRE RECEIVER OF PREFERRED RECEIVING EQUIPMENT
ORDER-WIRE RECEIVER OF STANDBY RECEIVING EQUIPMENT
TM 689-421

NOTE:
UNLESS OTHERWISE SHOWN:
RESISTORS ARE IN OHMS
CAPACITORS ARE IN UF.

Figure 279. Diversity audio connections, simplified schematic diagram.

taken from the standby receiver, K1 in the preferred receiver is released, K1′ in the standby receiver is operated, and —108-volt dc is applied to the grids of audio amplifiers V6A and V6B in the preferred order-wire receiver, cutting them off.

CHAPTER 7

FIELD MAINTENANCE

Note. The amount of repair that can be performed by units having field maintenance responsibility is limited only by the tools and test equipment available, and the skill of the repairman.

Section I. TROUBLESHOOTING AT FIELD MAINTENANCE LEVEL

Warning: When servicing this equipment be extremely careful of the high voltages exposed. Note the general precautions given in paragraph 222. With high voltage off, potentials as great as 300 volts still are present in the equipment. Keep one hand in the pocket when measuring socket voltages with probe. Before touching any part after voltage is shut off, short the part to ground.

219. Troubleshooting Procedures

The first procedure in servicing a defective radio set is to sectionalize the fault. Sectionalization means tracing the fault to the *major component* responsible for abnormal operation of the set. The second procedure is to localize the fault. Localization means tracing the fault to the defective *part* responsible for the abnormal operation. Some faults such as burned-out resistors, rf arcing, and shorted transformers often can be located by sight, smell, and hearing. The majority of faults, however, must be localized by checking *voltage and resistance* values.

a. Equipment Sectionalization. Equipment sectionalization is discussed in paragraph 129.

b. Component Sectionalization and Localization. The tests in (1) through (5) below aid in isolating the source of trouble. To be effective, the procedure should be followed in the order given. Remember that the servicing procedure followed should cause no further damage to the equipment. First, trouble should be localized to a single stage or circuit. Then the trouble may be isolated within that stage or circuit by appropriate voltage, resistance, and continuity measurements.

(1) *Visual inspection* (pars. 124 and 125). Through visual inspection alone, the repairman frequently may discover the trouble or determine the stage in which the trouble exists. This inspection is valuable in avoiding additional damage to the equipment that might occur through improper servicing methods and in forestalling future failures.

(2) *Input resistance measurements.* These measurements prevent further damage to the equipment from possible short circuit.

(3) *Operational test.* The operational test (par. 224) is important because it frequently indicates the general location of trouble. In many instances, the information gained will determine the exact nature of the fault. To use this information fully, all symptoms must be interpreted in relation to one another.

(4) *Troubleshooting chart.* The trouble symptoms listed in these charts will aid greatly in localizing trouble.

(5) *Final test and adjustment.* The final test and adjustment procedures can be used to determine that trouble exists in a component, and to sectionalize the trouble.

220. Troubleshooting Figure References

The following troubleshooting data will help in rapid location of faults.

a. Order-Wire Transmitter.

Par. No.	Fig. No.	Description
	280	Order-wire transmitter, tube-socket voltage and resistance chart.
	281	Order-wire transmitter, right hand front view.
	282	Order-wire transmitter, rear view.
	283	Order-wire transmitter, rear oblique view.
	284	Order-wire transmitter, bottom oblique view.
228	------	Dc resistance of transformers and coils.
	410	Order-wire transmitter, schematic diagram.
	430	Order-wire transmitter, wiring diagram.

b. Radio Transmitter.

Par. No.	Fig. No.	Description
	285	Radio modulator, tube socket voltage and resistance diagram.
	286	Crystal multiplier, tube socket voltage and resistance diagram.
	287	If. amplifier, tube socket voltage and resistance diagram.
	288	Chopper amplifier, tube socket voltage and resistance diagram.
	289	Electronic voltage regulator, tube socket voltage and resistance diagram.
	290	Vtvm, tube socket voltage and resistance diagram.
	291	Transmitter klystron, tube socket voltage and resistance diagram.
	292	Radio modulator, left hand front view.
	293	Radio modulator, bottom view.
	294	Crystal multiplier, top view.
	295	Crystal multiplier, rear view.
	296	If. amplifier, front view.
	297	If. amplifier, rear view.
	298	Chopper amplifier, left hand rear view.
	299	Chopper amplifier, front view.
	300	Chopper amplifier, right hand rear view.
	301	Vtvm, front view.
	302	Vtvm, rear view.
	303	Meter panel, left hand rear view.
	304	Meter panel, rear view.
	305	Electronic voltage regulator, oblique bottom view.
228	------	Dc resistances of transformers and coils.
	402	Radio transmitter, overall schematic diagram.
	403	Radio modulator, schematic diagram.
	404	Crystal multiplier, schematic diagram.
	405	If. amplifier, schematic diagram.
	406	Chopper amplifier, schematic diagram.

b. Radio Transmitter (cont).

Par. No.	Fig. No.	Description
	407	Vtvm, schematic diagram.
	408	Meter panel, schematic diagram.
	409	Electronic voltage regulator, schematic diagram.
	421	Radio transmitter, overall chassis wiring diagram.
	423	Radio modulator, wiring diagram.
	424	Crystal multiplier, wiring diagram.
	425	If. amplifier, wiring diagram.
	426	Chopper amplifier, wiring diagram.
	427	Vtvm, wiring diagram.
	428	Meter panel, wiring diagram.
	429	Electronic voltage regulator, wiring diagram.

c. High-Voltage Power Supply PP–764/G.

Par. No.	Fig. No.	Description
	306	High-voltage power supply tube socket voltage and resistance diagram.
	307	High-voltage power supply terminal board voltage and resistance diagram.
	308	High-voltage power supply, oblique top view.
	309	High-voltage power supply, bottom view.
	310	High-voltage power supply, rear view, cover removed.
	311	High-voltage power supply, front view.
228	------	Dc resistance of transformers and coils.
	411	High-voltage power supply schematic diagram.
	431	High-voltage power supply wiring diagram.

d. Transmitter Rack. Transmitter rack interconnecting diagram is shown in figure 401.

e. Order-Wire Receiver.

Par. No.	Fig. No.	Description
	312	Order-wire receiver, left hand front view.
	313	Order-wire receiver, right hand front view.
	314	Order-wire receiver, rear view.
	315	Order-wire receiver, rear oblique view.
	316	Order-wire receiver, oblique of rear.
	317	Order-wire receiver, top view.
	318	Order-wire receiver, side view.
	319	Order-wire receiver, tube socket voltage and resistance diagram.
228	------	Dc resistances of transformers and coils.
	399	Order-wire receiver, schematic diagram.
	419	Order-wire receiver, wiring diagram.

f. Radio Receiver.

Par. No.	Fig. No.	Description
	320	If. preamplifier, tube socket voltage and resistance diagram.
	321	If. amplifier, tube socket voltage and resistance diagram.
	322	Video amplifier, tube socket voltage and resistance diagram.
	323	Afc circuits, tube socket voltage and resistance diagram.
	324	Agc and afc dc amplifiers, tube socket voltage and resistance diagram.
	325	Local oscillator, tube socket voltage and resistance diagram.
	326	If. preamplifier, front view.
	327	If. preamplifier, rear view.
	328	If. amplifier, front view.
	329	If. amplifier, rear view.
	330	Video amplifier, front view.
	331	Video amplifier, rear view, right oblique.
	332	Video amplifier, rear view, left oblique.
	333	Afc circuits, front view.
	334	Afc circuits, rear view.
	335	Agc and afc dc amplifiers, front view.
	336	Agc and afc dc amplifiers, rear view.
	337	Agc and afc dc amplifiers, side view.
	392	Radio receiver, overall schematic diagram.
	218	Preselector mixer, schematic diagram.
	220	Local oscillator, schematic diagram.
	394	Afc circuits, schematic diagram.
	395	If. preamplifier, schematic diagram.
	396	If. amplifier, schematic diagram.
	397	Video amplifier, schematic diagram.
	398	Afc and agc dc amplifier, schematic diagram.
	413	Radio receiver, overall wiring diagram.
	414	Afc circuits, wiring diagram.
	415	If. preamplifier, wiring diagram.
	416	If. amplifier, wiring diagram.
	417	Video amplifier, wiring diagram.
	418	Afc and agc dc amplifiers, wiring diagram.
228	------	Dc resistances of transformers and coils.

g. Receiver Power Supply PP–690/G.

Par. No.	Fig. No.	Description
	338	Receiver power supply, tube socket voltage and resistance diagram.
	339	Receiver power supply terminal strip, voltages and resistance diagram.
	340	Receiver power supply, front view.
	341	Receiver power supply, rear view.
	342	Receiver power supply, rear view, terminal board swung down.
	343	Receiver power supply, upper rear view.
	344	Receiver power supply, lower rear view.
228	------	Dc resistances of transformers and coils.
	400	Receiver power supply, schematic diagram.
	420	Receiver power supply, wiring diagram.

h. Low-Voltage Power Supply PP–689/G.

Par. No.	Fig. No.	Description
	345	Low-voltage power supply, tube socket voltage and resistance diagram.
	346	Low-voltage power supply, front view.
	347	Low-voltage power supply, left hand rear view.
	348	Low-voltage power supply, top rear view.
228	------	Dc resistances of transformers and coils.
	412	Low-voltage power supply, schematic diagram.
	432	Low-voltage power supply, wiring diagram.

i. Receiver Rack Cabling. Interconnections between components of the receiver rack are shown in figure 391.

221. Test Equipment Required for Troubleshooting

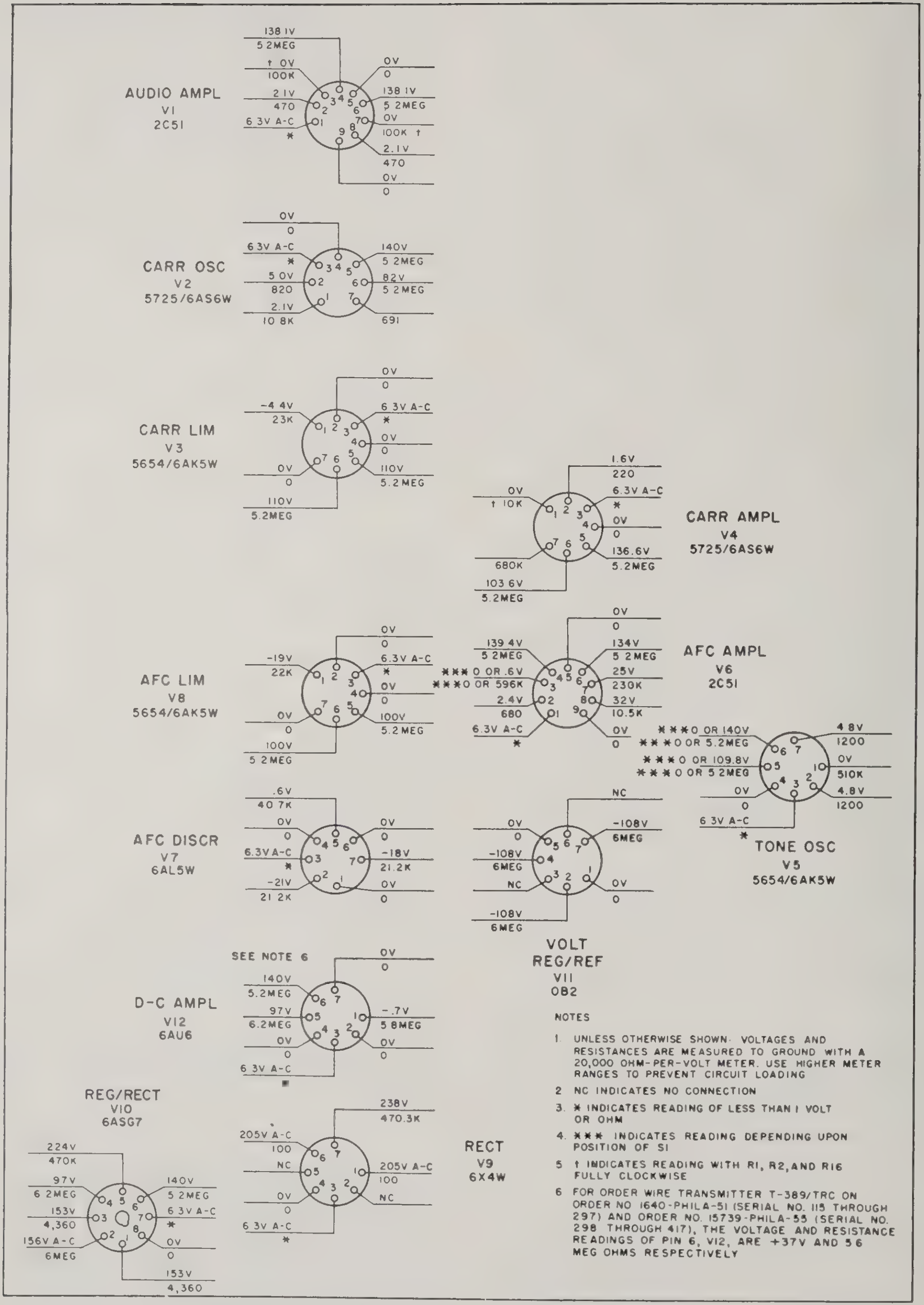
The test equipment required for troubleshooting Radio Set AN/TRC–29 is listed below. Technical manuals associated with the test equipment are also listed.

Test equipment	Technical manual
Audio Oscillator TS–382/U or equal	TM 11–2684
Electronic Multimeter TS–505/U	TM 11–5511
Oscilloscope AN/USM–50	
Voltmeter ME–30A/U	
Electron Tube Test Set TV–2/U	TM 11–2661
Electron Tube Test Set TV–7/U	TM 11–5083
Multimeter TS–352/U	TM 11–5527
RF Signal Generator AN/URM–25D	TM 11–5551
Signal Generator AN/URM–61	
Signal Generator AN/URM–64	
Signal Generator TS–497A/URR	TM 11–5030
Sweep Generator SG–92/U	TM 11–319
Wattmeter ME–69/U	
Frequency Meter AN/URM–32	
Frequency Meter AN/URM–79	TM 11–5094
Frequency Meter AN/URM–80	TM 11–5095

222. General Precautions

Whenever equipment is serviced, follow these precautions carefully:

a. Be careful when the protective back cover is removed. Do not pull out the safety interlock (that is *cheat* on interlock) unless it is neces- to apply voltage to the chassis.


AUDIO AMPL
V1
2C51
138 1V
5 2MEG
† 0V
100K
2 1V
470
6 3V A-C
*
0V
0
138 1V
5 2MEG
0V
100K †
2.1V
470
0V
0
CARR OSC
V2
5725/6AS6W
0V
0
6 3V A-C
*
5 0V
820
2.1V
10 8K
140V
5 2MEG
82V
5 2MEG
691
CARR LIM
V3
5654/6AK5W
-4 4V
23K
0V
0
110V
5.2MEG
0V
0
6 3V A-C
*
0V
0
110V
5.2MEG
CARR AMPL
V4
5725/6AS6W
0V
† 10K
680K
103 6V
5.2MEG
1.6V
220
6.3V A-C
*
0V
0
136.6V
5.2MEG
AFC LIM
V8
5654/6AK5W
-19V
22K
0V
0
100V
5 2MEG
0V
0
6.3V A-C
*
0V
0
100V
5.2MEG
AFC AMPL
V6
2C51
139.4V
5 2MEG
*** 0 OR .6V
*** 0 OR 596K
2.4V
680
6.3V A-C
*
0V
0
134V
5 2MEG
25V
230K
32V
10.5K
0V
0
TONE OSC
V5
5654/6AK5W
*** 0 OR 140V
*** 0 OR 5.2MEG
*** 0 OR 109.8V
*** 0 OR 5 2MEG
0V
0
6 3V A-C
*
4 8V
1200
0V
510K
4.8V
1200
AFC DISCR
V7
6AL5W
.6V
40 7K
0V
0
6.3V A-C
*
-21V
21 2K
0V
0
-18V
21.2K
0V
0
VOLT
REG/REF
V11
0B2
NC
0V
0
-108V
6MEG
NC
-108V
6MEG
-108V
6MEG
0V
0
D-C AMPL
V12
6AU6
SEE NOTE 6
140V
5.2MEG
97V
6.2MEG
0V
0
6 3V A-C
*
0V
0
-.7V
5 8MEG
0V
0
REG/RECT
V10
6ASG7
224V
470K
97V
6 2MEG
153V
4,360
156V A-C
6MEG
140V
5 2MEG
6 3V A-C
*
0V
0
153V
4,360
RECT
V9
6X4W
238V
470.3K
205V A-C
100
NC
0V
0
6 3V A-C
*
205V A-C
100
NC

NOTES

1. UNLESS OTHERWISE SHOWN· VOLTAGES AND RESISTANCES ARE MEASURED TO GROUND WITH A 20,000 OHM-PER-VOLT METER. USE HIGHER METER RANGES TO PREVENT CIRCUIT LOADING
2. NC INDICATES NO CONNECTION
3. * INDICATES READING OF LESS THAN I VOLT OR OHM
4. *** INDICATES READING DEPENDING UPON POSITION OF SI
5. † INDICATES READING WITH RI, R2, AND R16 FULLY CLOCKWISE
6. FOR ORDER WIRE TRANSMITTER T-389/TRC ON ORDER NO 1640-PHILA-51 (SERIAL NO. 115 THROUGH 297) AND ORDER NO. 15739-PHILA-55 (SERIAL NO. 298 THROUGH 417), THE VOLTAGE AND RESISTANCE READINGS OF PIN 6, V12, ARE +37V AND 5 6 MEG OHMS RESPECTIVELY

TM 689-467

Figure 280. Order-wire transmitter, tube socket voltage and resistance chart.

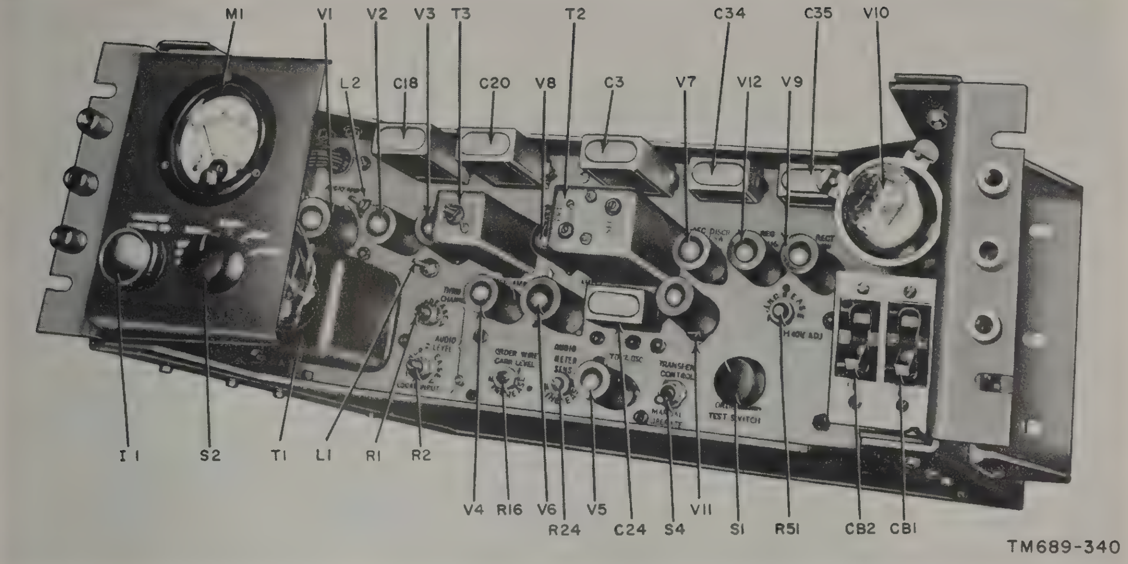

M1
V1
V2
V3
T3
T2
C34
C35
V10
L2
C18
C20
V8
C3
V7
V12
V9
I1
S2
T1
L1
R1
R2
V4
R16
V6
R24
V5
C24
S4
V11
S1
R51
CB2
CB1
TM689-340

Figure 281. Order-wire transmitter, right hand front view.

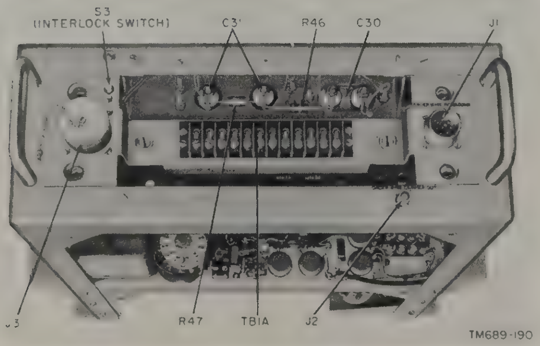

S3
(INTERLOCK SWITCH)
C3'
R46
C30
J1
J3
R47
TB1A
J2
TM689-190

Figure 282. Order-wire transmitter, rear view.

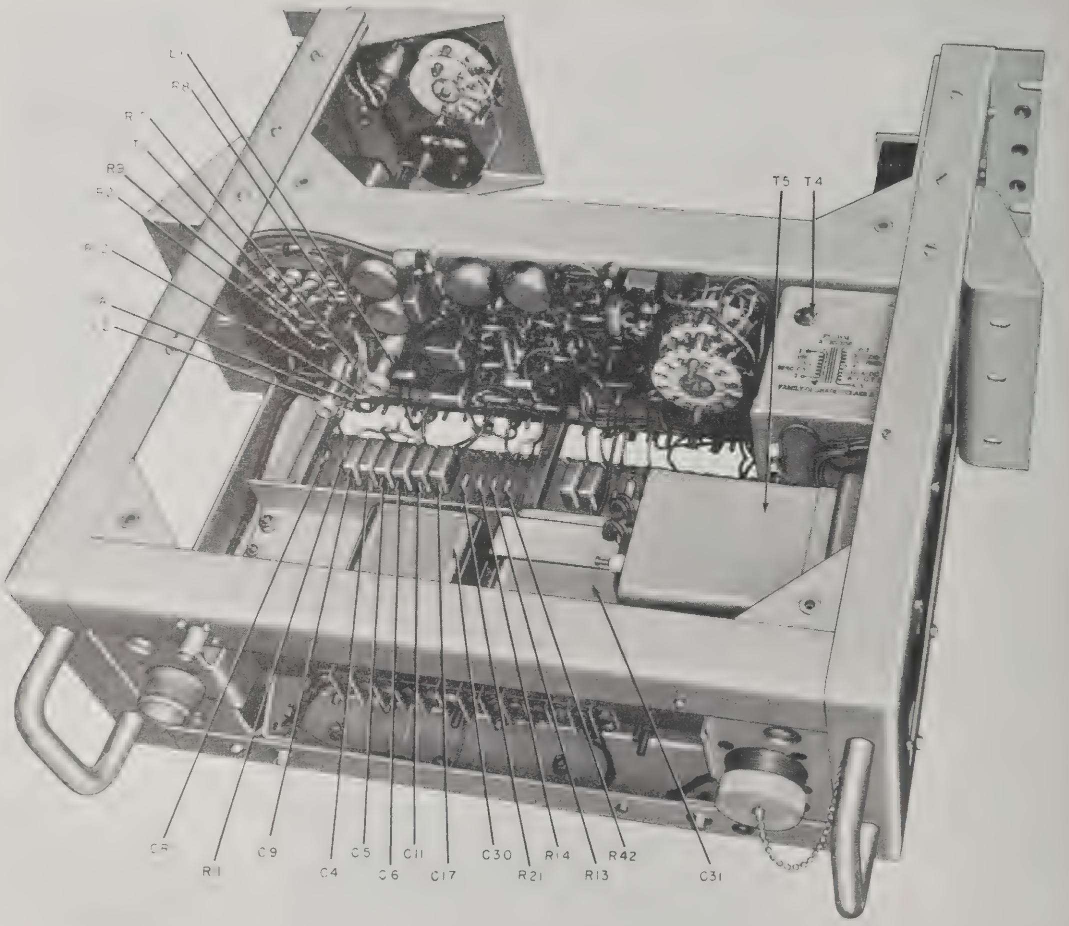

R8
R9
T5
T4
C8
R11
C9
C4
C5
C6
C11
C17
C30
R21
R14
R13
R42
C31
TM689-185

Figure 283. Order-wire transmitter, rear oblique view.

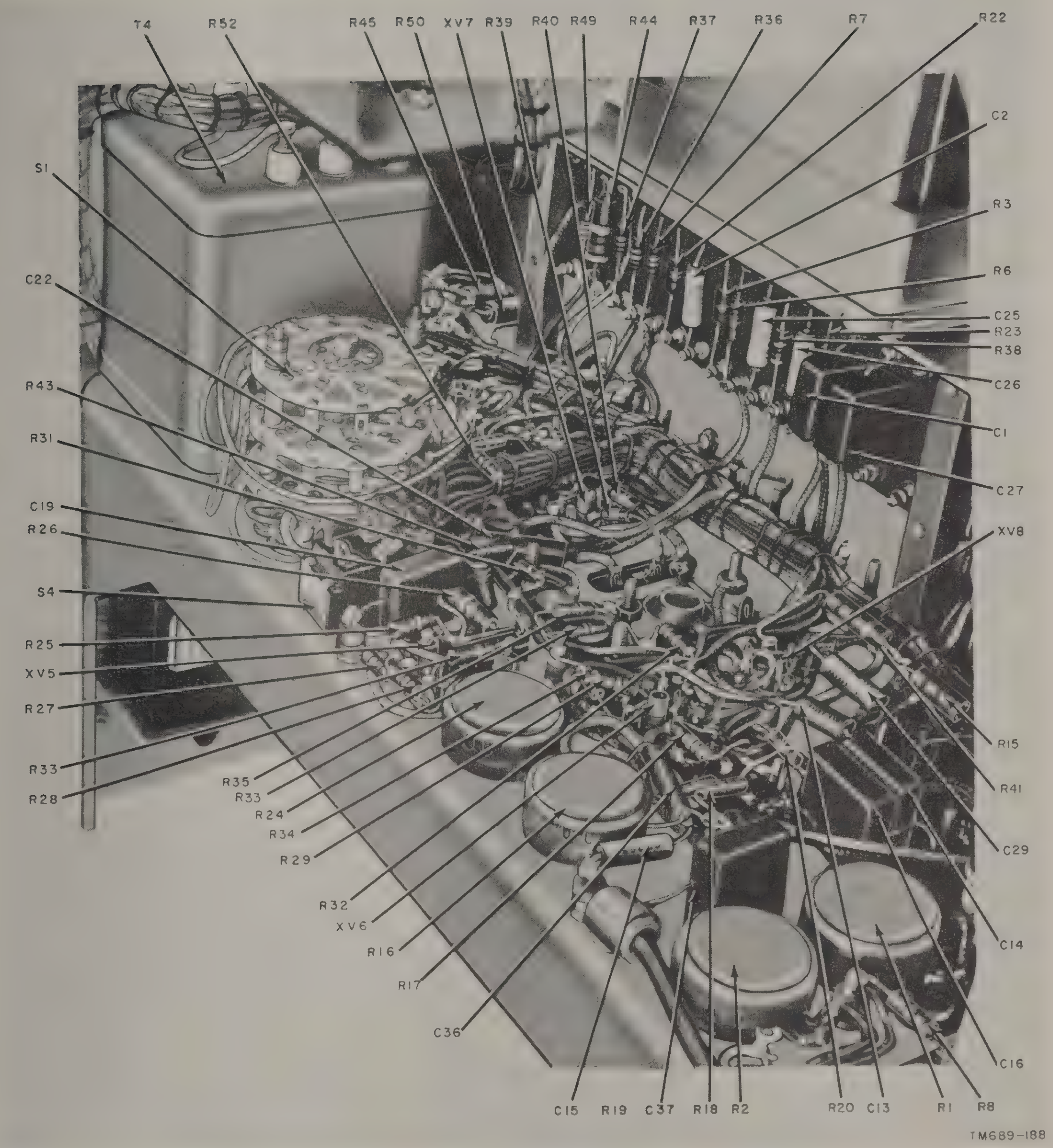
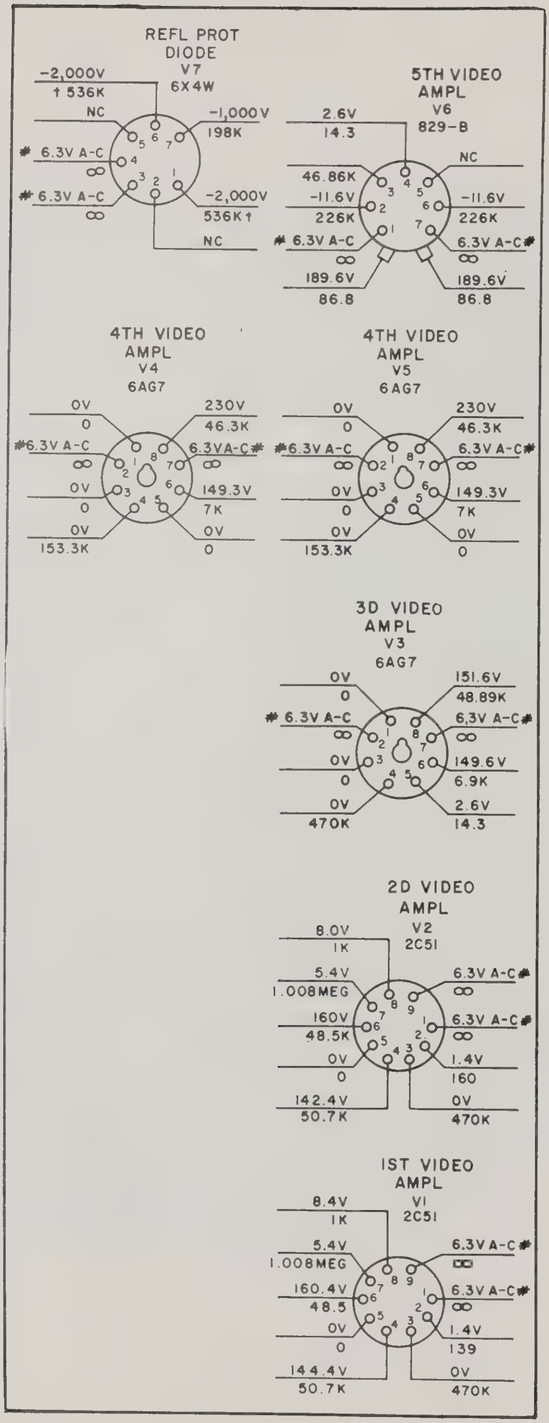

T4
R52
R45
R50
XV7
R39
R40
R49
R44
R37
R36
R7
R22
C2
R3
R6
C25
R23
R38
C26
C1
C27
XV8
R15
R41
C29
C14
C16
S1
C22
R43
R31
C19
R26
S4
R25
XV5
R27
R33
R28
R35
R33
R24
R34
R29
R32
XV6
R16
R17
C36
C15
R19
C37
R18
R2
R20
C13
R1
R8
TM689-188

Figure 284. Order-wire transmitter, bottom oblique view.

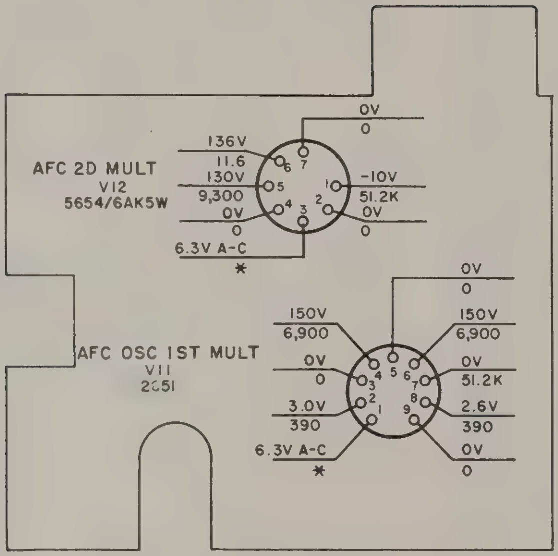

REFL PROT DIODE
V7
6X4W
-2,000V
† 536K
NC
# 6.3V A-C
∞
# 6.3V A-C
∞
-1,000V
198K
-2,000V
536K†
NC
5TH VIDEO AMPL
V6
829-B
2.6V
14.3
NC
46.86K
-11.6V
226K
# 6.3V A-C
∞
-11.6V
226K
6.3V A-C#
∞
189.6V
86.8
189.6V
86.8
4TH VIDEO AMPL
V4
6AG7
0V
0
#6.3V A-C
∞
0V
0
0V
153.3K
230V
46.3K
6.3VA-C#
∞
149.3V
7K
0V
0
4TH VIDEO AMPL
V5
6AG7
0V
0
#6.3V A-C
∞
0V
0
0V
153.3K
230V
46.3K
6.3V A-C#
∞
149.3V
7K
0V
0
3D VIDEO AMPL
V3
6AG7
0V
0
# 6.3V A-C
∞
0V
0
0V
470K
151.6V
48.89K
6,3V A-C#
∞
149.6V
6.9K
2.6V
14.3
2D VIDEO AMPL
V2
2C51
8.0V
1K
5.4V
1.008MEG
160V
48.5K
0V
0
142.4V
50.7K
6.3V A-C#
∞
6.3V A-C#
∞
1.4V
160
0V
470K
1ST VIDEO AMPL
V1
2C51
8.4V
1K
5.4V
1.008MEG
160.4V
48.5
0V
0
144.4V
50.7K
6.3V A-C#
∞
6.3V A-C#
∞
1.4V
139
0V
470K

NOTES:

1. UNLESS OTHERWISE SHOWN: VOLTAGES AND RESISTANCES ARE MEASURED TO GROUND WITH A 20,000 OHM-PER-VOLT METER. USE HIGHER METER RANGES TO PREVENT CIRCUIT LOADING
2. NC INDICATES NO CONNECTION
3. † INDICATES READING WITH R250 FULLY CLOCKWISE
4 # INDICATES FILAMENT READING BETWEEN FILAMENT PINS

TM689-456

Figure 285. Radio modulator, tube socket voltage and resistance diagram.

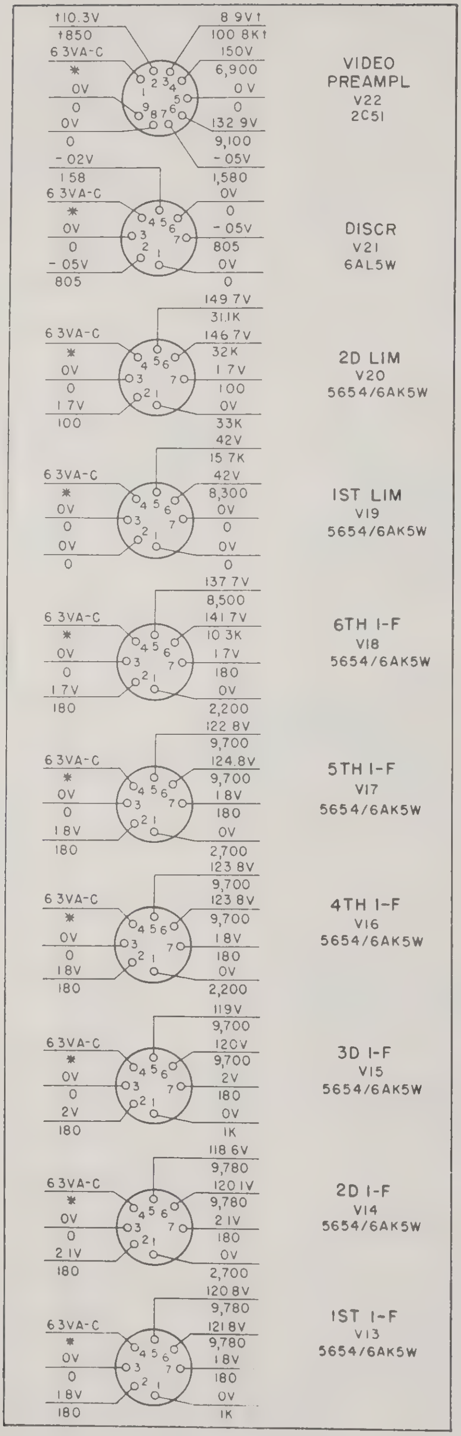

AFC 2D MULT
V12
5654/6AK5W
136V
11.6
130V
9,300
0V
0
6.3V A-C
*
0V
0
-10V
51.2K
0V
0
1
2
3
4
5
6
7
AFC OSC 1ST MULT
V11
2C51
150V
6,900
0V
0
3.0V
390
6.3V A-C
*
0V
0
150V
6,900
0V
51.2K
2.6V
390
0V
0
1
2
3
4
5
6
7
8
9

NOTES:

1. UNLESS OTHERWISE SHOWN: VOLTAGES AND RESISTANCES ARE MEASURED TO GROUND WITH A 20,000 OHM-PER-VOLT METER. USE HIGHER METER RANGES TO PREVENT CIRCUIT LOADING.
2. * INDICATES READING OF LESS THAN 1 VOLT OR OHM

TM 689-453

Figure 286. Crystal multiplier, tube socket voltage and resistance diagram.

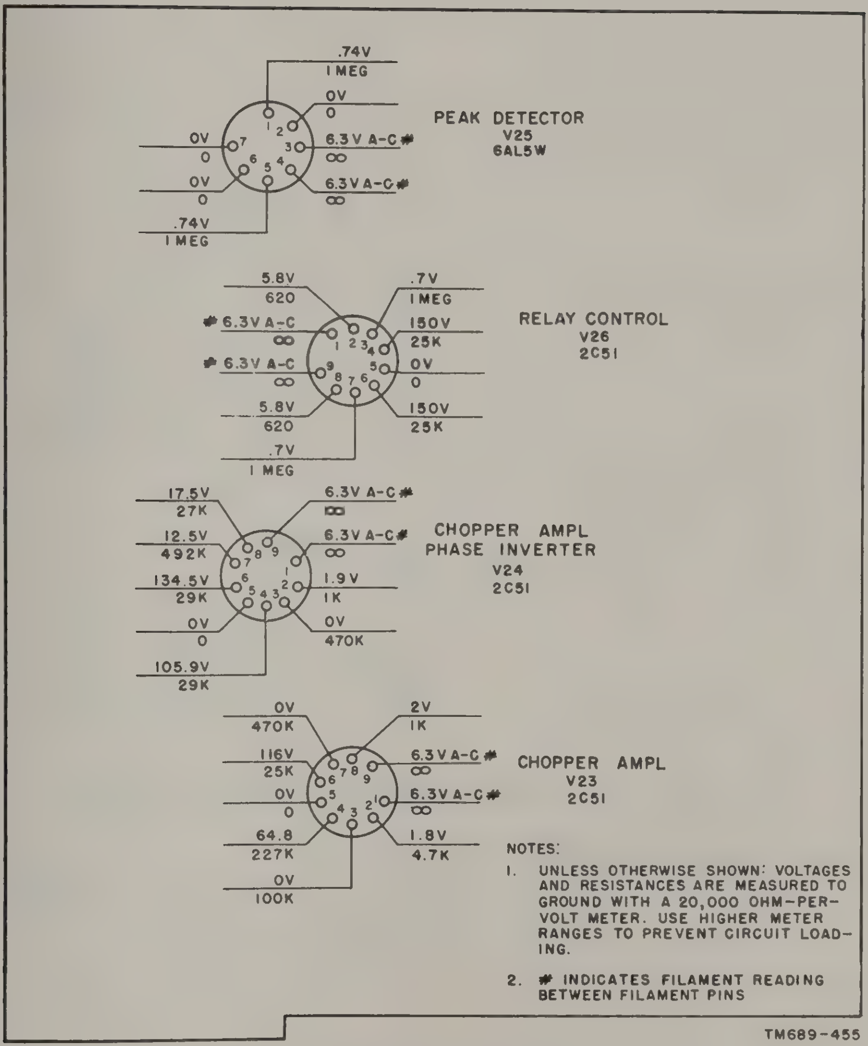

†10.3V
†850
6 3VA-C
✱
0V
0
0V
0
- 02V
8 9V†
100 8K†
150V
6,900
0 V
0
132 9V
9,100
- 05V
VIDEO PREAMPL
V22
2C51
1 58
6 3VA-C
✱
0V
0
- 05V
805
1,580
0V
0
- 05V
805
0V
0
DISCR
V21
6AL5W
149 7V
31.1K
146 7V
32K
1 7V
100
0V
33K
6 3VA-C
✱
0V
0
1 7V
100
2D LIM
V20
5654/6AK5W
42V
15 7K
42V
8,300
0V
0
0V
0
6 3VA-C
✱
0V
0
0V
0
IST LIM
V19
5654/6AK5W
137 7V
8,500
141 7V
10 3K
1 7V
180
0V
2,200
6 3VA-C
✱
0V
0
1 7V
180
6TH I-F
V18
5654/6AK5W
122 8V
9,700
124.8V
9,700
1 8V
180
0V
2,700
6 3VA-C
✱
0V
0
1 8V
180
5TH I-F
V17
5654/6AK5W
123 8V
9,700
123 8V
9,700
1 8V
180
0V
2,200
6 3VA-C
✱
0V
0
1 8V
180
4TH I-F
V16
5654/6AK5W
119V
9,700
120V
9,700
2V
180
0V
1K
6 3VA-C
✱
0V
0
2V
180
3D I-F
V15
5654/6AK5W
118 6V
9,780
120 1V
9,780
2 1V
180
0V
2,700
6 3VA-C
✱
0V
0
2 1V
180
2D I-F
V14
5654/6AK5W
120 8V
9,780
121 8V
9,780
1 8V
180
0V
1K
6 3VA-C
✱
0V
0
1 8V
180
IST I-F
V13
5654/6AK5W

NOTES:

1. UNLESS OTHERWISE SHOWN: VOLTAGES AND RESISTANCES ARE MEASURED TO GROUND WITH A 20,000 OHM-PER-VOLT METER. USE HIGHER METER RANGES TO PREVENT CIRCUIT LOADING
2. ✱ INDICATES READING OF LESS THAN 1 VOLT OR OHM
3. † INDICATES READING WITH R135 FULLY CLOCKWISE

TM 689-457

Figure 287. If. amplifier, tube socket voltage and resistance diagram.


.74V
1 MEG
0V
0
PEAK DETECTOR
V25
6AL5W
0V
0
6.3V A-C #
∞
0V
0
6.3V A-C #
∞
.74V
1 MEG
5.8V
620
.7V
1 MEG
# 6.3V A-C
∞
150V
25K
RELAY CONTROL
V26
2C51
# 6.3V A-C
∞
0V
0
5.8V
620
150V
25K
.7V
1 MEG
17.5V
27K
6.3V A-C #
∞
12.5V
492K
6.3V A-C #
∞
CHOPPER AMPL
PHASE INVERTER
V24
2C51
134.5V
29K
1.9V
1K
0V
0
0V
470K
105.9V
29K
0V
470K
2V
1K
116V
25K
6.3V A-C #
∞
CHOPPER AMPL
V23
2C51
0V
0
6.3V A-C #
∞
64.8
227K
1.8V
4.7K
0V
100K

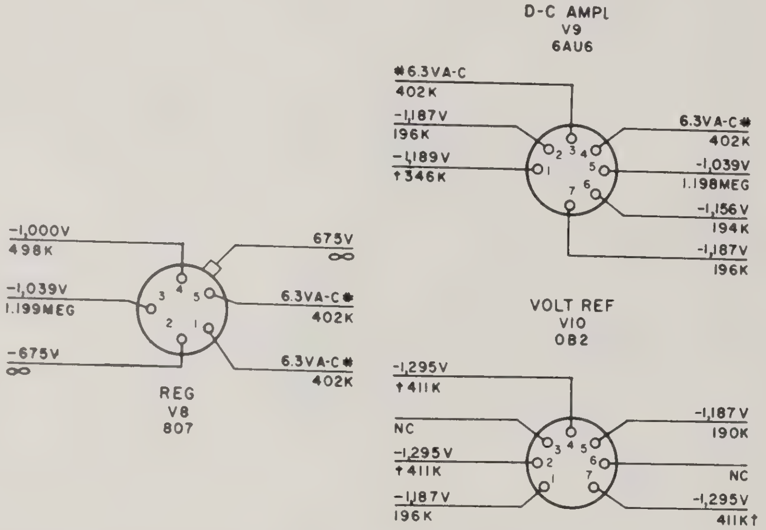
NOTES:

1. UNLESS OTHERWISE SHOWN: VOLTAGES AND RESISTANCES ARE MEASURED TO GROUND WITH A 20,000 OHM-PER-VOLT METER. USE HIGHER METER RANGES TO PREVENT CIRCUIT LOADING.

2. # INDICATES FILAMENT READING BETWEEN FILAMENT PINS

TM689-455

Figure 288. Chopper amplifier, tube socket voltage and resistance diagram.

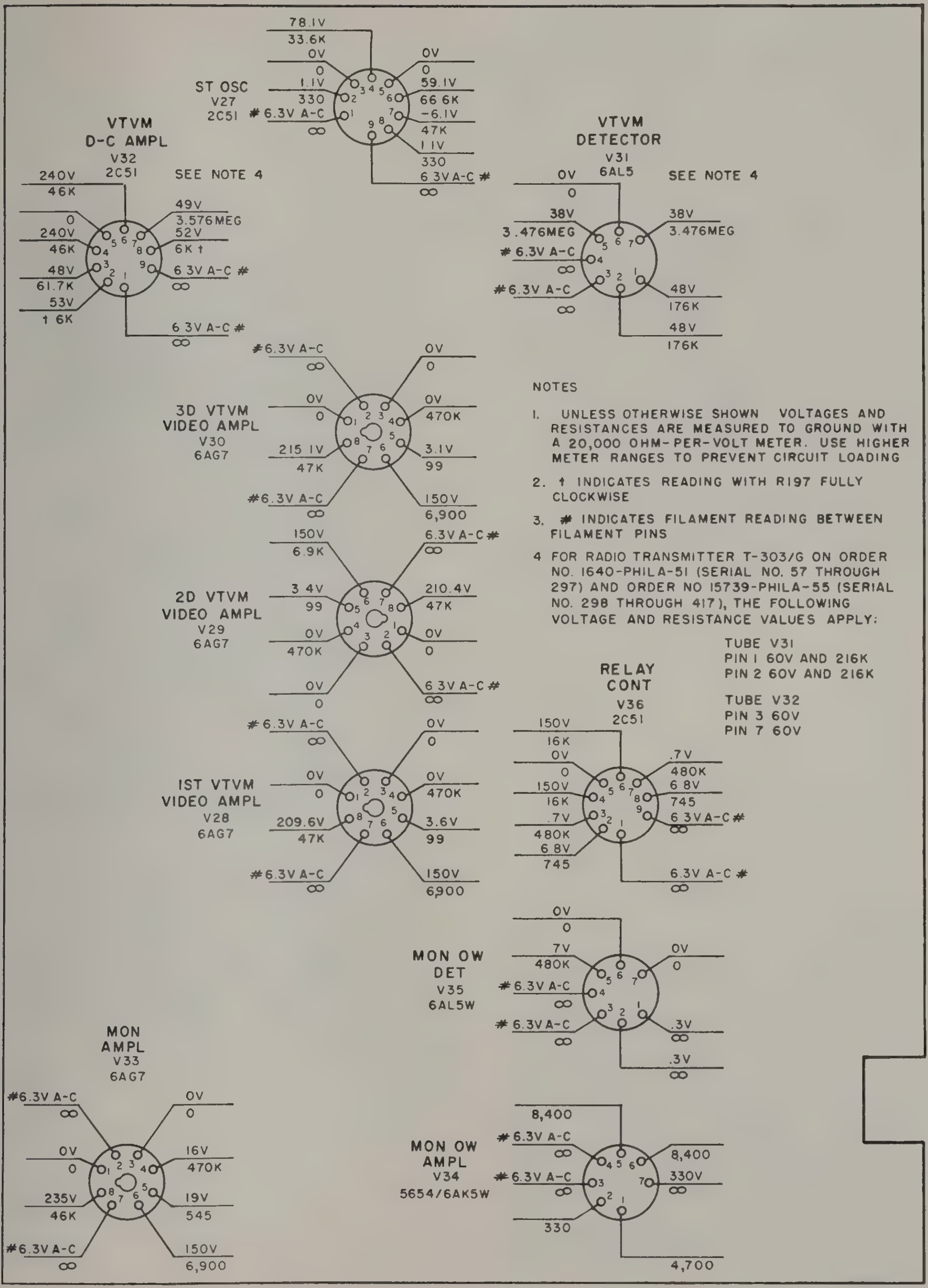

D-C AMPL
V9
6AU6
✱6.3VA-C
402K
-1,187V
196K
-1,189V
†346K
6.3VA-C✱
402K
-1,039V
1.198MEG
-1,156V
194K
-1,187V
196K
1
2
3
4
5
6
7
-1,000V
498K
675V
∞
-1,039V
1.199MEG
6.3VA-C✱
402K
-675V
∞
6.3VA-C✱
402K
1
2
3
4
5
REG
V8
807
VOLT REF
V10
OB2
-1,295V
†411K
NC
-1,295V
†411K
-1,187V
196K
-1,187V
190K
NC
-1,295V
411K†
1
2
3
4
5
6
7

NOTES:

1. UNLESS OTHERWISE SHOWN: VOLTAGES AND RESISTANCES ARE MEASURED TO GROUND WITH A 20,000 OHM PER VOLT METER. USE HIGHER METER RANGES TO PREVENT CIRCUIT LOADING.
2. NC INDICATES NO CONNECTION
3. † INDICATES READING WITH R72 AND R250 FULLY CLOCKWISE
4. ✱ INDICATES FILAMENT READING BETWEEN FILAMENT PINS

TM689-454

Figure 289. Electronic voltage regulator, tube socket voltage and resistance diagram.


ST OSC
V27
2C51
78.1V
33.6K
0V
0
1.1V
330
# 6.3V A-C
∞
0V
0
59.1V
66 6K
-6.1V
47K
1 1V
330
6 3V A-C #
∞
VTVM
D-C AMPL
V32
2C51
SEE NOTE 4
240V
46K
0
240V
46K
48V
61.7K
53V
1 6K
49V
3.576MEG
52V
6K †
6 3V A-C #
∞
6 3V A-C #
∞
VTVM
DETECTOR
V31
6AL5
SEE NOTE 4
0V
0
38V
3.476MEG
# 6.3V A-C
∞
# 6.3V A-C
∞
38V
3.476MEG
48V
176K
48V
176K
3D VTVM
VIDEO AMPL
V30
6AG7
#6.3V A-C
∞
0V
0
215 1V
47K
#6.3V A-C
∞
0V
0
0V
470K
3.1V
99
150V
6,900
2D VTVM
VIDEO AMPL
V29
6AG7
150V
6.9K
3 4V
99
0V
470K
0V
0
6.3V A-C #
∞
210.4V
47K
0V
0
6 3V A-C #
∞
IST VTVM
VIDEO AMPL
V28
6AG7
# 6.3V A-C
∞
0V
0
209.6V
47K
#6.3V A-C
∞
0V
0
0V
470K
3.6V
99
150V
6,900
RELAY
CONT
V36
2C51
150V
16K
0V
0
150V
16K
.7V
480K
6.8V
745
.7V
480K
6 8V
745
6 3V A-C #
∞
6.3V A-C #
∞
MON OW
DET
V35
6AL5W
0V
0
7V
480K
# 6.3V A-C
∞
# 6.3V A-C
∞
0V
0
.3V
∞
.3V
∞
MON
AMPL
V33
6AG7
#6.3V A-C
∞
0V
0
235V
46K
#6.3V A-C
∞
0V
0
16V
470K
19V
545
150V
6,900
MON OW
AMPL
V34
5654/6AK5W
8,400
# 6.3V A-C
∞
# 6.3V A-C
∞
330
8,400
330V
∞
4,700
TM 689-458

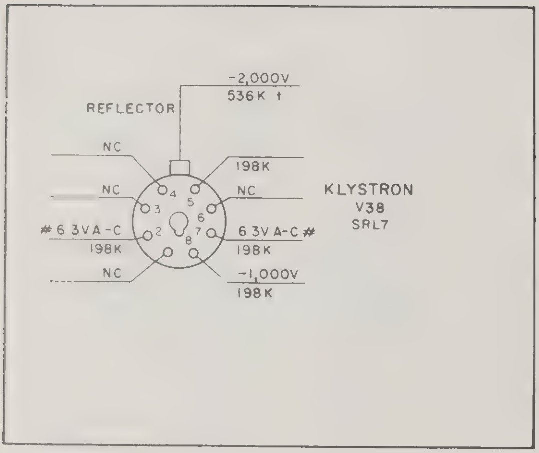
NOTES

1. UNLESS OTHERWISE SHOWN VOLTAGES AND RESISTANCES ARE MEASURED TO GROUND WITH A 20,000 OHM-PER-VOLT METER. USE HIGHER METER RANGES TO PREVENT CIRCUIT LOADING
2. † INDICATES READING WITH R197 FULLY CLOCKWISE
3. # INDICATES FILAMENT READING BETWEEN FILAMENT PINS
4. FOR RADIO TRANSMITTER T-303/G ON ORDER NO. 1640-PHILA-51 (SERIAL NO. 57 THROUGH 297) AND ORDER NO 15739-PHILA-55 (SERIAL NO. 298 THROUGH 417), THE FOLLOWING VOLTAGE AND RESISTANCE VALUES APPLY:

TUBE V31
PIN 1 60V AND 216K
PIN 2 60V AND 216K

TUBE V32
PIN 3 60V
PIN 7 60V

Figure 290. Vtvm tube socket and resistance diagram.

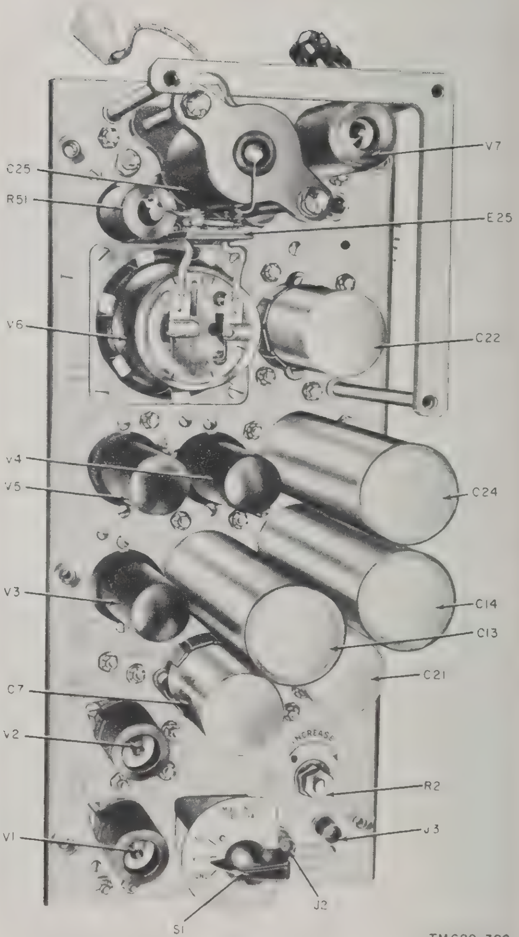

-2,000V
536K †
REFLECTOR
NC
198K
NC
NC
KLYSTRON
V38
SRL7
#6.3VA-C
198K
6.3VA-C#
198K
NC
-1,000V
198K
1
2
3
4
5
6
7
8

NOTE

1. UNLESS OTHERWISE SHOWN: VOLTAGES AND RESISTANCES ARE MEASURED TO GROUND WITH A 20,000 OHM-PER-VOLT METER. USE HIGHER METER RANGES TO PREVENT CIRCUIT LOADING.
2. NC INDICATES NO CONNECTION
3. † INDICATES READING WITH R250 FULLY CLOCKWISE
4. # INDICATES FILAMENT READING BETWEEN FILAMENT PINS

TM689-468

Figure 291. Transmitter klystron, tube socket voltage and resistance diagram.


V7
C25
R51
E25
V6
C22
V4
V5
C24
V3
C14
C13
C21
C7
V2
INCREASE
R2
V1
J3
J2
S1

TM689-309

Figure 292. Radio modulator, left hand front view.

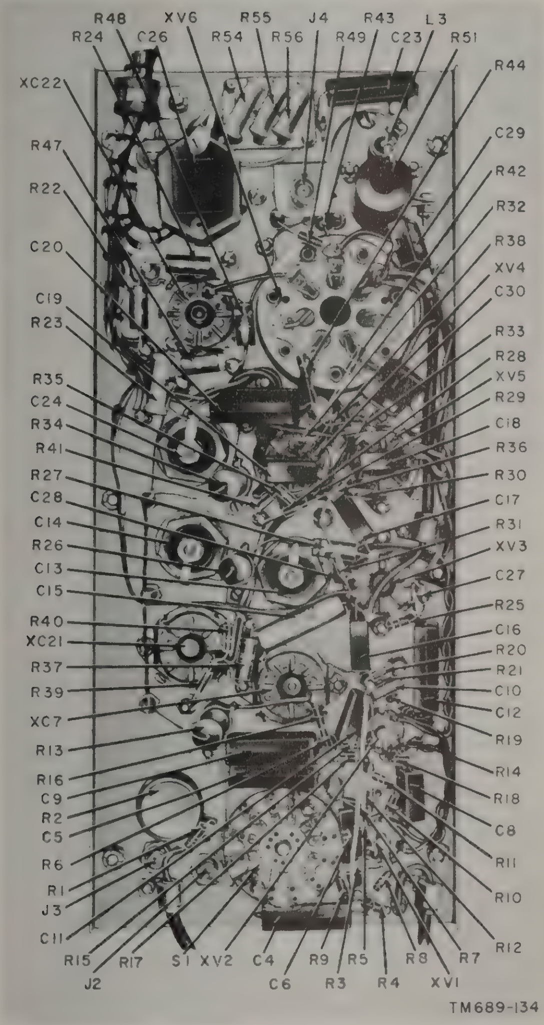

R48
XV6
R55
J4
R43
L3
R24
C26
R54
R56
R49
C23
R51
XC22
R44
R47
C29
R22
R42
R32
C20
R38
XV4
C19
C30
R23
R33
R28
R35
XV5
C24
R29
R34
C18
R41
R36
R30
R27
C17
C28
R31
C14
XV3
R26
C27
C13
C15
R25
R40
C16
XC21
R20
R37
R21
R39
C10
XC7
C12
R13
R19
R16
R14
C9
R18
R2
C5
C8
R6
R11
R1
R10
J3
C11
R12
R15
R17
S1
XV2
C4
R9
R5
R8
R7
J2
C6
R3
R4
XV1
TM689-134

Figure 293. Radio modulator, bottom view.

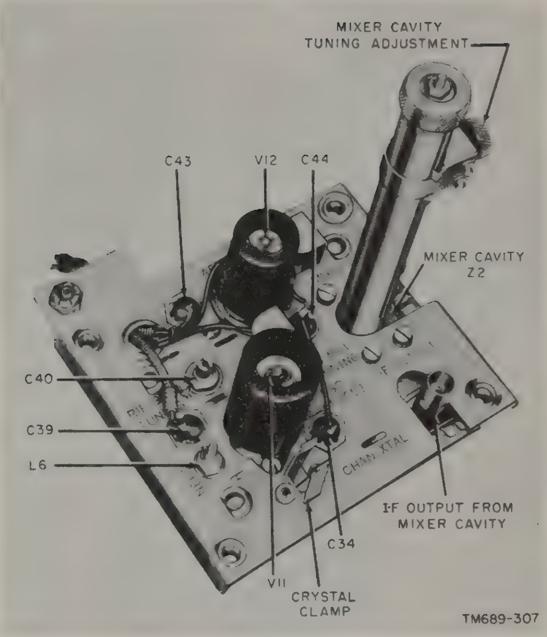

MIXER CAVITY
TUNING ADJUSTMENT
C43
V12
C44
MIXER CAVITY
Z2
C40
C39
L6
CHAN XTAL
I-F OUTPUT FROM
MIXER CAVITY
C34
V11
CRYSTAL
CLAMP
TM689-307

Figure 294. Crystal multiplier, top view.

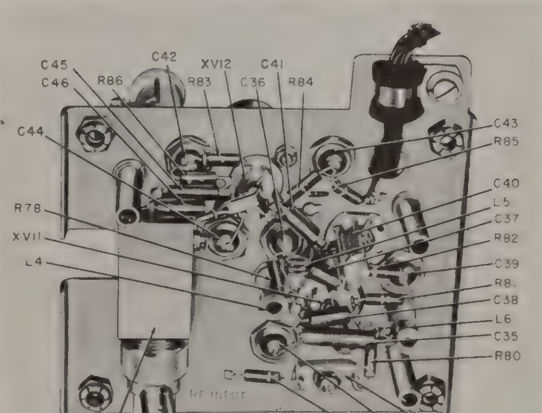

C45
C42
XV12
C41
C46
R86
R83
C36
R84
C44
C43
R85
C40
L5
R78
C37
XV11
R82
L4
C39
R81
C38
L6
C35
R80
RF INPUT
MIXER CAVITY
Z2
R-F INPUT TO
MIXER CAVITY
R79
C34
XY1
TM689-137

Figure 295. Crystal multiplier, rear view.

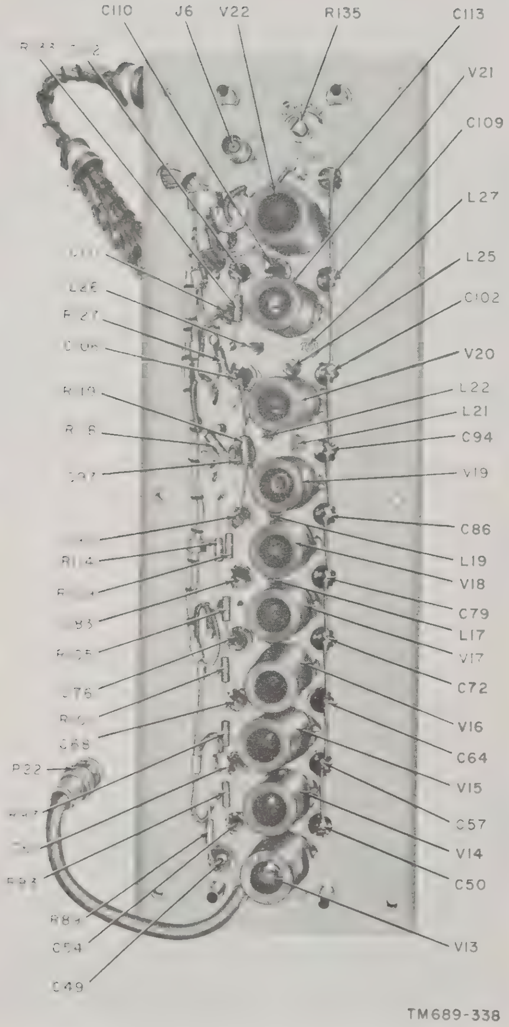

C110
J6
V22
R135
C113
V21
C109
L27
L25
C102
V20
L22
L21
C94
V19
C86
L19
V18
C79
L17
V17
C72
V16
C64
V15
C57
V14
C50
V13
L26
R114
P22
R84
C54
C49
TM689-338

Figure 296. If. amplifier, front view.

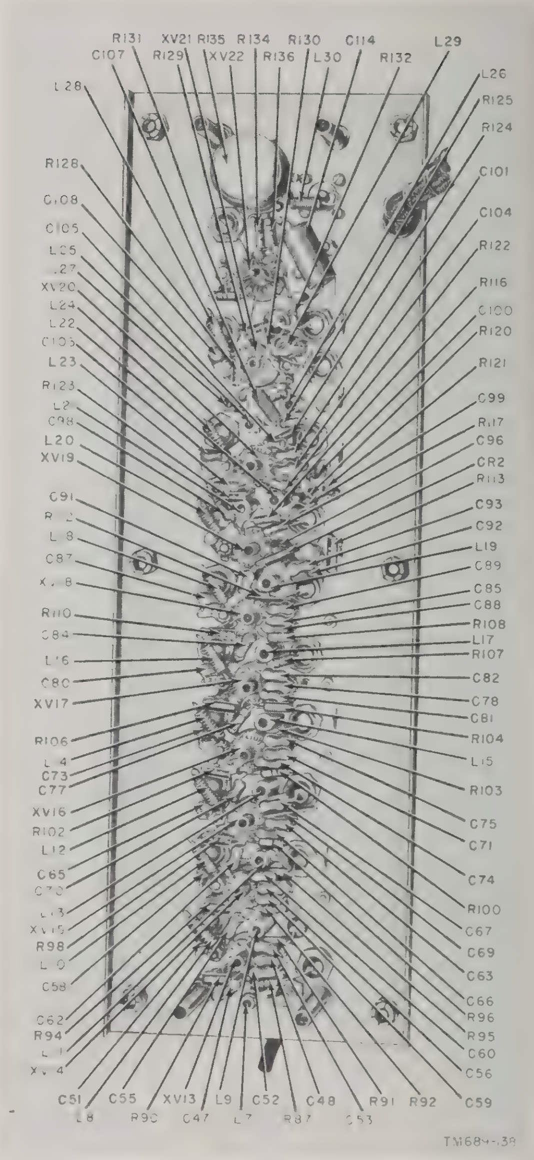
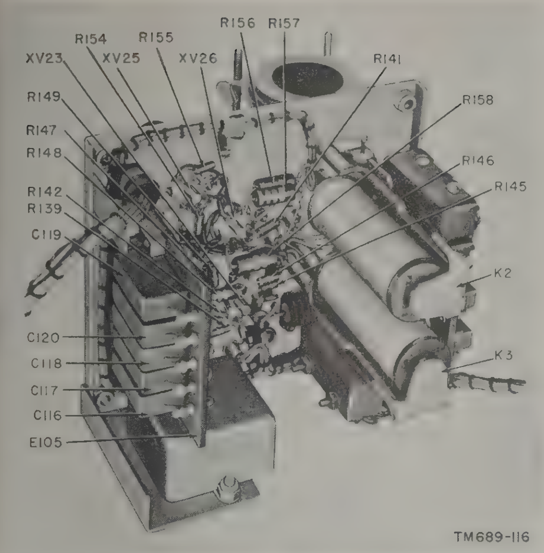
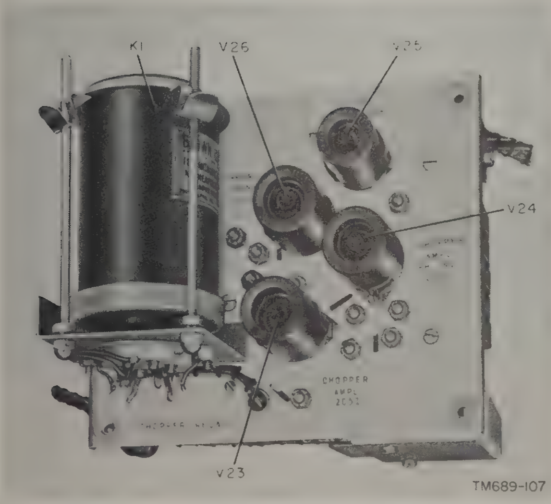

R131
XV21
R135
R134
R130
C114
L29
C107
R129
XV22
R136
L30
R132
L28
L26
R125
R124
R128
C108
C101
C105
C104
L25
R122
XV20
R116
L24
C100
L22
R120
C103
L23
R121
R123
C99
C98
R117
L20
C96
XV19
CR2
R113
C91
C93
C92
L19
C87
C89
C85
C88
R110
R108
C84
L17
R107
C82
C80
C78
XV17
C81
R106
R104
L15
C73
R103
C77
XV16
C75
R102
C71
L12
C65
C74
R100
C67
R98
C69
C63
C58
C66
C62
R96
R94
R95
C60
C56
C51
C55
XV13
L9
C52
C48
R91
R92
C59
R90
C47
R87
C53
TM689-339

Figure 297. If. amplifier, rear view.


R156
R157
R154
R155
XV23
XV25
XV26
R141
R149
R158
R147
R146
R148
R145
R142
R139
C119
K2
C120
C118
K3
C117
C116
E105

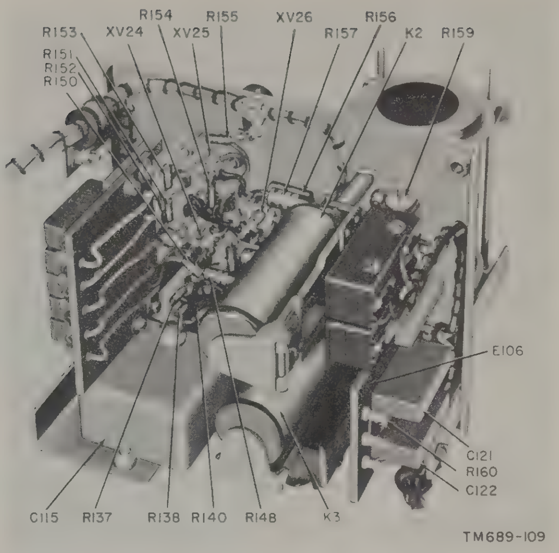
TM689-116

Figure 298. Chopper amplifier, left hand rear view.


K1
V26
V25
V24
V23
CHOPPER
AMPL

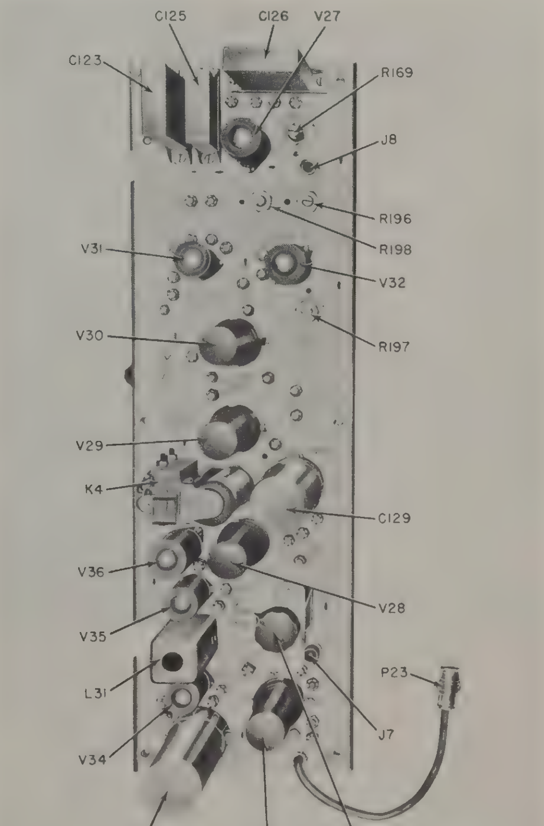
TM689-107

Figure 299. Chopper amplifier, front view.


R154
R155
XV26
R156
R153
XV24
XV25
R157
K2
R159
R151
R152
R150
E106
C121
R160
C122
C115
R137
R138
R140
R148
K3

TM689-109

Figure 300. Chopper amplifier, right hand rear view.


C125
C126
V27
C123
R169
J8
R196
R198
V31
V32
V30
R197
V29
K4
C129
V36
V28
V35
P23
L31
J7
V34
C139
V33
S2

TM689-336

Figure 301. Vtvm, front view.

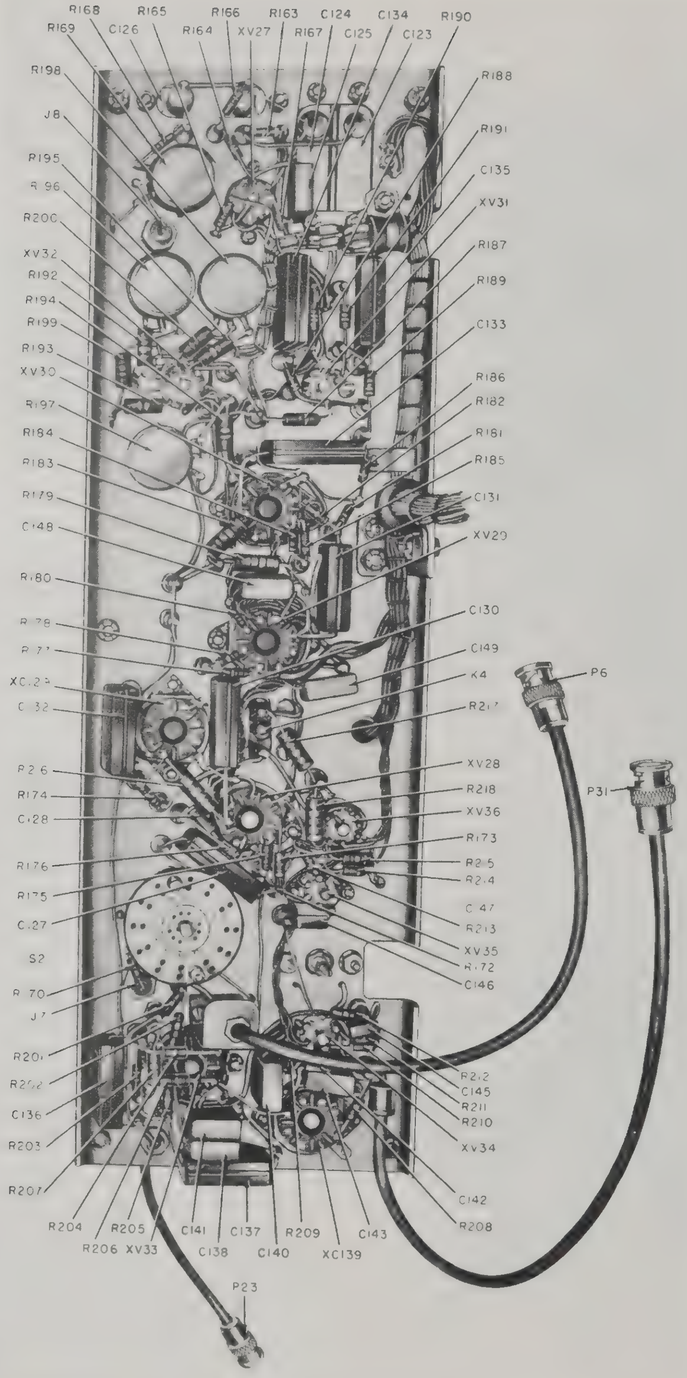

R168
R165
R166
R163
C124
C134
R190
R169
C126
R164
XV27
R167
C125
C123
R198
R188
J8
R191
R195
C135
R196
XV31
R200
R187
XV32
R192
R189
R194
R199
C133
R193
XV30
R186
R182
R197
R181
R184
R185
R183
R179
C131
C148
XV29
R180
C130
R178
R177
C149
XC129
K4
C132
R217
XV28
R216
R218
R174
XV36
C128
R173
R176
R215
R214
R175
C147
C127
R213
XV35
S2
R172
C146
R170
J7
R201
R212
R202
C145
R211
C136
R210
XV34
R203
C142
R207
R208
R204
R205
C141
C137
R209
C143
R206
XV33
C138
C140
XC139
P6
P31
P23
TM 689-164

Figure 302. Vtvm, rear view.

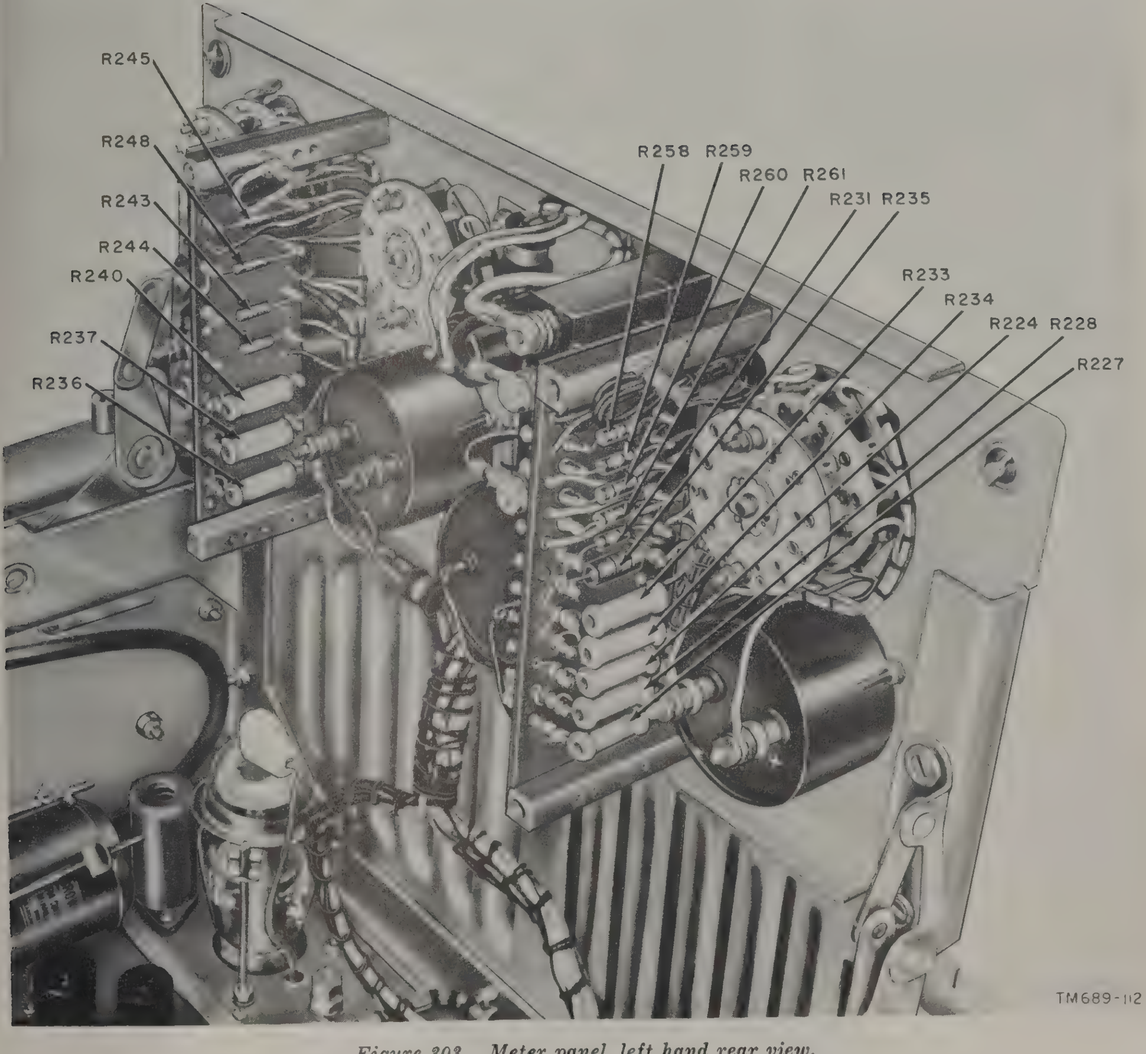

R245
R248
R243
R244
R240
R237
R236
R258 R259
R260 R261
R231 R235
R233
R234
R224 R228
R227
TM689-112

Figure 303. Meter panel, left hand rear view.

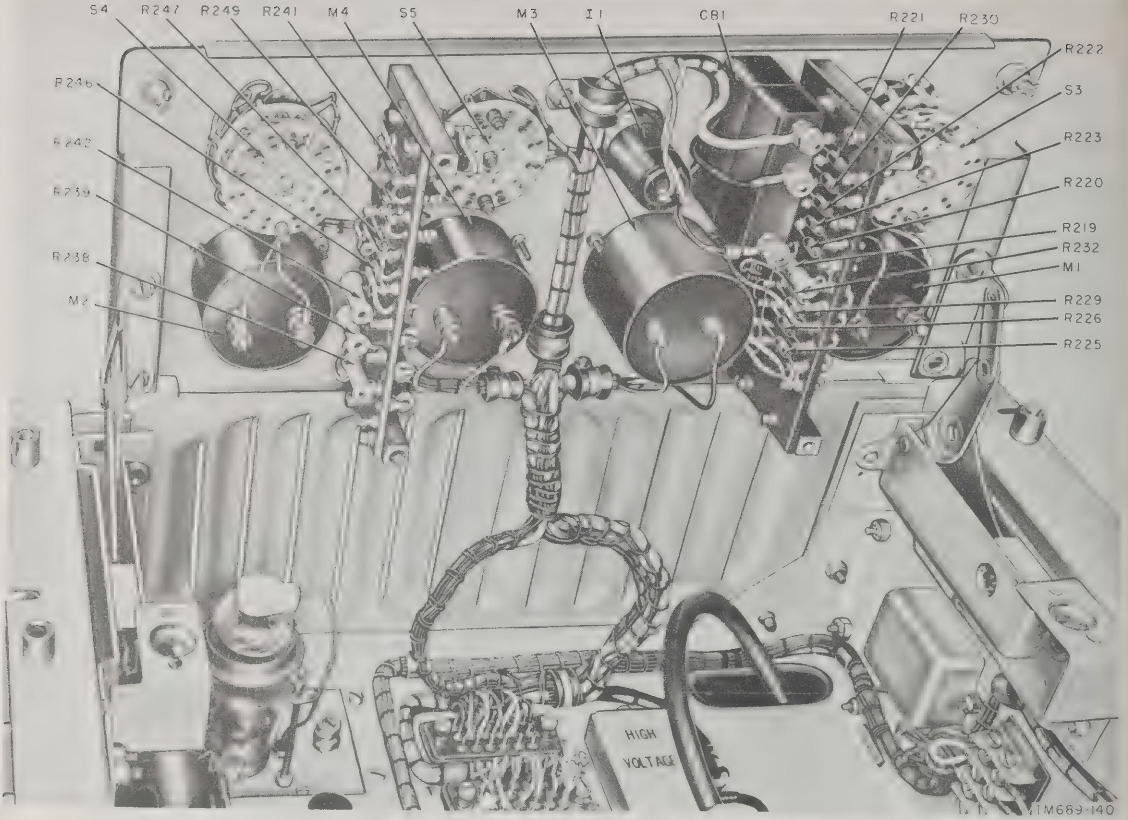

S4
R247
R249
R241
M4
S5
M3
I1
C81
R221
R230
R222
S3
R223
R220
R219
R232
M1
R229
R226
R225
R246
R242
R239
R238
M2
HIGH VOLTAGE
TM689-140

Figure 304. Meter panel, rear view.

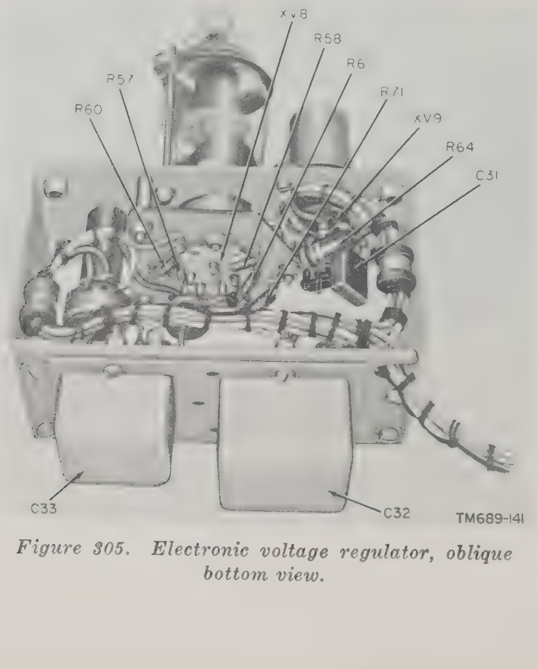
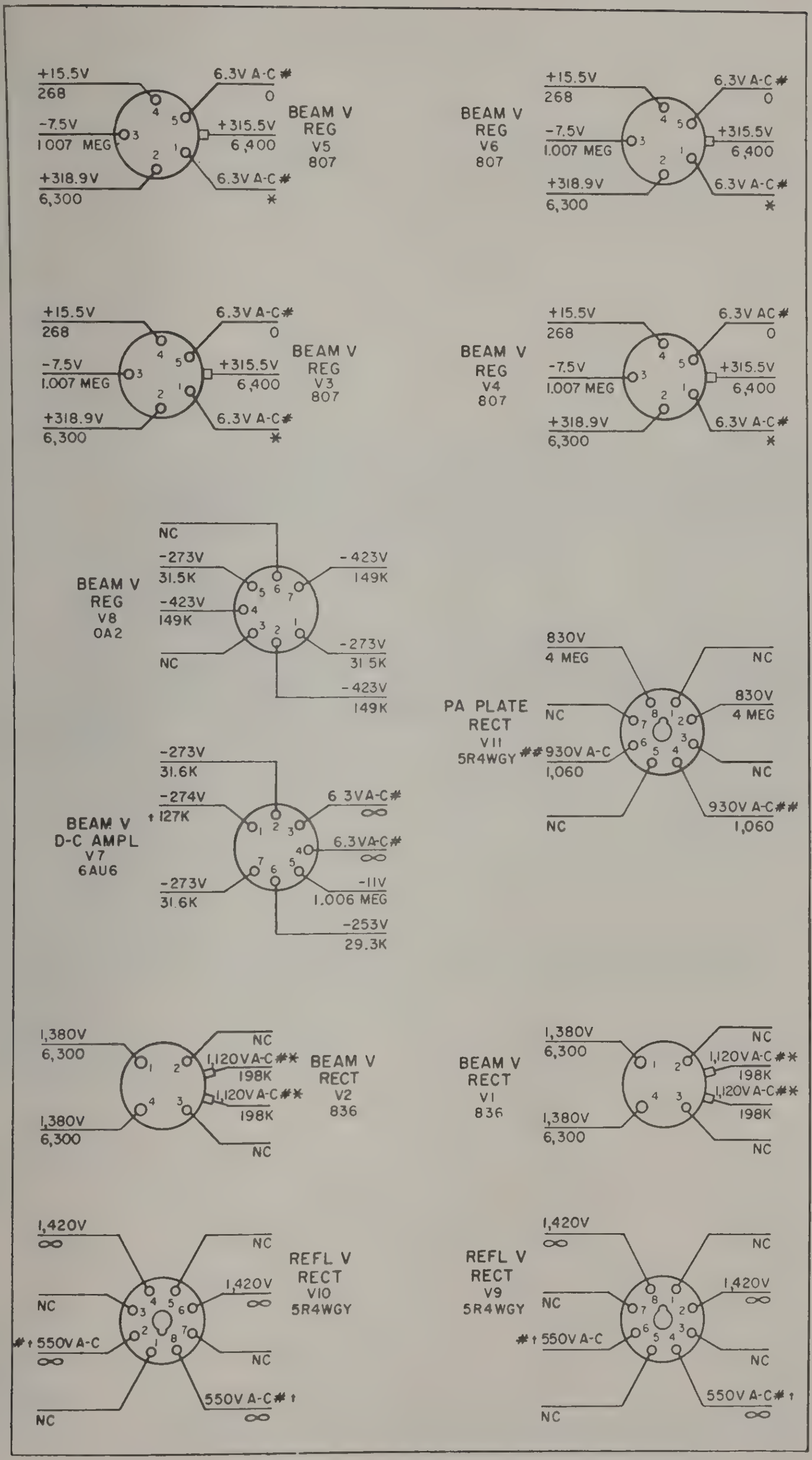

XV8
R58
R6
R57
R60
R71
XV9
R64
C31
C33
C32
TM689-141

Figure 305. Electronic voltage regulator, oblique bottom view.

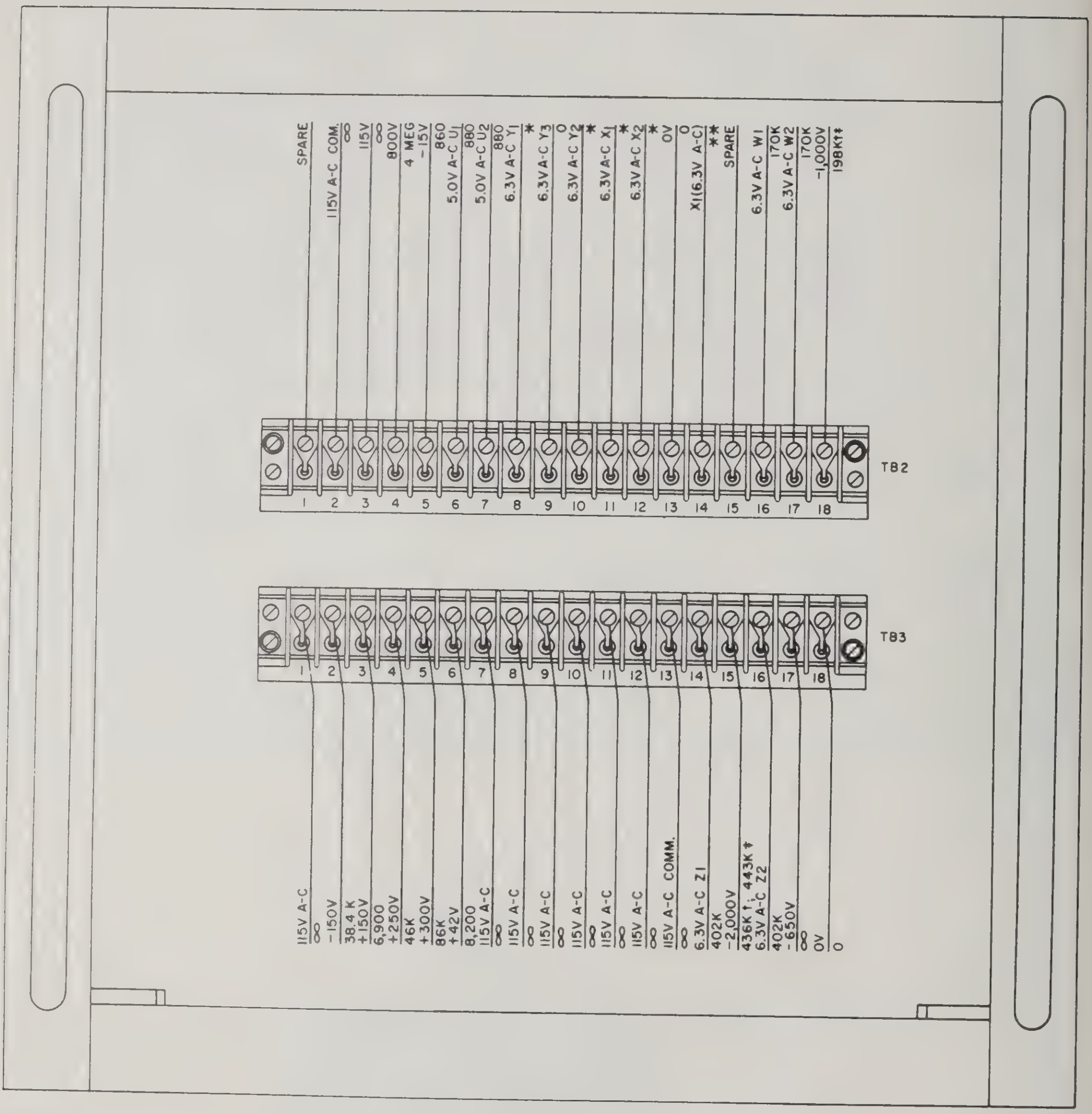

+15.5V
268
-7.5V
1.007 MEG
+318.9V
6,300
6.3V A-C #
0
+315.5V
6,400
6.3V A-C #
*
BEAM V
REG
V5
807
BEAM V
REG
V6
807
+15.5V
268
-7.5V
1.007 MEG
+318.9V
6,300
6.3V A-C #
0
+315.5V
6,400
6.3V A-C #
*
+15.5V
268
-7.5V
1.007 MEG
+318.9V
6,300
6.3V A-C #
0
+315.5V
6,400
6.3V A-C #
*
BEAM V
REG
V3
807
BEAM V
REG
V4
807
+15.5V
268
-7.5V
1.007 MEG
+318.9V
6,300
6.3V AC #
0
+315.5V
6,400
6.3V A-C #
*
BEAM V
REG
V8
0A2
NC
-273V
31.5K
-423V
149K
NC
-423V
149K
-273V
31 5K
-423V
149K
PA PLATE
RECT
V11
5R4WGY
830V
4 MEG
NC
NC
## 930V A-C
1,060
NC
NC
830V
4 MEG
NC
930V A-C ##
1,060
BEAM V
D-C AMPL
V7
6AU6
-273V
31.6K
-274V
† 127K
-273V
31.6K
6 3VA-C #
∞
6.3VA-C #
∞
-11V
1.006 MEG
-253V
29.3K
1,380V
6,300
1,380V
6,300
NC
1,120VA-C #*
198K
1,120VA-C #*
198K
NC
BEAM V
RECT
V2
836
BEAM V
RECT
V1
836
1,380V
6,300
1,380V
6,300
NC
1,120VA-C #*
198K
1,120VA-C #*
198K
NC
1,420V
∞
NC
#† 550VA-C
∞
NC
NC
1,420V
∞
NC
550V A-C #†
∞
REFL V
RECT
V10
5R4WGY
REFL V
RECT
V9
5R4WGY
1,420V
∞
NC
#† 550V A-C
NC
NC
1,420V
∞
NC
550V A-C #†
∞

NOTES:

1. UNLESS OTHERWISE SHOWN: VOLTAGES AND RESISTANCES ARE MEASURED TO GROUND WITH A 20,000 OHM PER VOLT METER. USE HIGHER METER RANGES TO PREVENT CIRCUIT LOADING.
2. NC INDICATES NO CONNECTION
3. * INDICATES READING OF LESS THAN ONE VOLT OR OHM
4. † INDICATES READING WITH R36 FULLY CLOCKWISE
5. # INDICATES FILAMENT READING BETWEEN FILAMENT PINS
6. ## INDICATES READING BETWEEN TUBE PINS AND TERMINAL 4 OF T4
7. #* INDICATES READING BETWEEN TUBE PINS AND TERMINAL 6 OF T2
8. #† INDICATES READING BETWEEN TUBE PINS AND TERMINAL 3 OF T2

TM 689-465

Figure 306. High-voltage power supply tube socket voltage and resistance diagram.


SPARE
115V A-C COM.
∞
115V
∞
800V
4 MEG
-15V
860
5.0V A-C U1
880
5.0V A-C U2
880
6.3V A-C Y1
*
6.3V A-C Y3
0
6.3V A-C Y2
*
6.3V A-C X1
*
6.3V A-C X2
*
0V
0
X1(6.3V A-C)
**
SPARE
6.3V A-C W1
170K
6.3V A-C W2
170K
-1,000V
198K†‡
TB2
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
TB3
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
115V A-C
∞
-150V
38.4 K
+150V
6,900
+250V
46K
+300V
86K
+42V
8,200
115V A-C
∞
115V A-C
∞
115V A-C
∞
115V A-C
∞
115V A-C
∞
115V A-C
∞
115V A-C COMM.
∞
6.3V A-C Z1
402K
-2,000V
436K†; 443K‡
6.3V A-C Z2
402K
-650V
∞
0V
0

NOTES:

1. UNLESS OTHERWISE SHOWN:
   VOLTAGES AND RESISTANCES ARE MEASURED TO GROUND WITH A 20,000 OHM-PER-VOLT METER. USE HIGHER METER RANGES TO PREVENT CIRCUIT LOADING.
2. * INDICATES READING OF LESS THAN 1 OHM
3. † INDICATES READING WITH R250 CW
4. ‡ INDICATES READING WITH R250 CCW
5. ** INDICATES READING OF LESS THAN 1 OHM WITH S9 CLOSED

TM 689-488

Figure 307. High-voltage power supply terminal board voltage and resistance diagram.

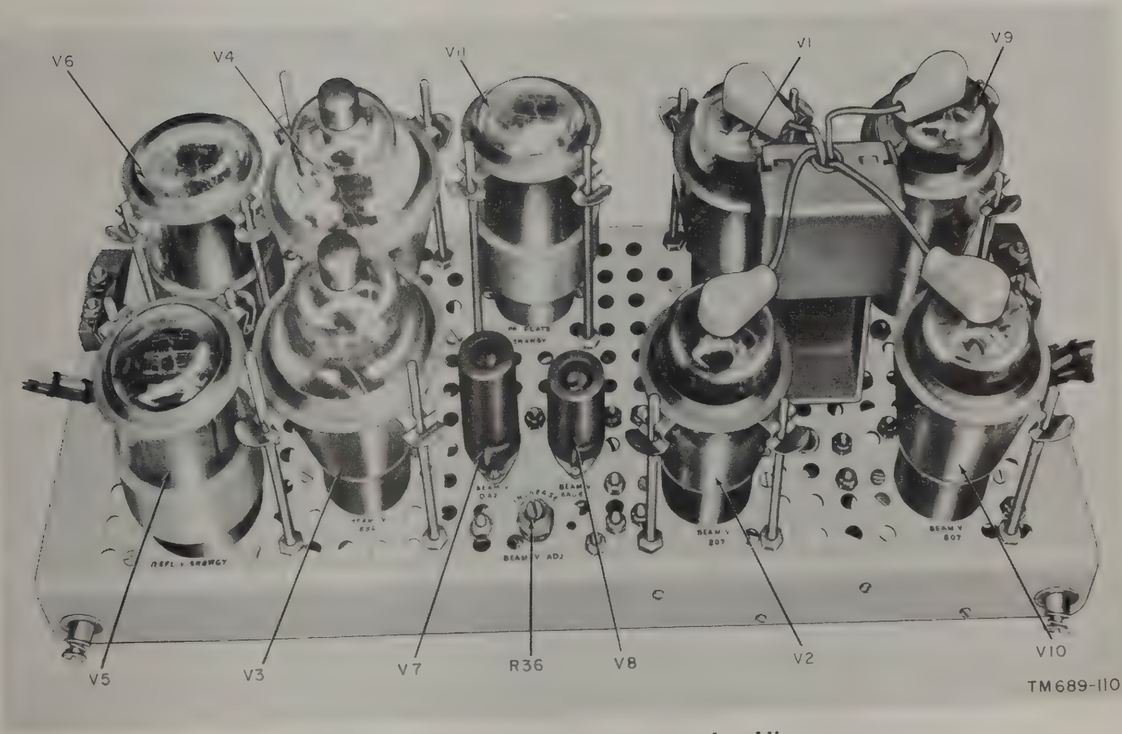
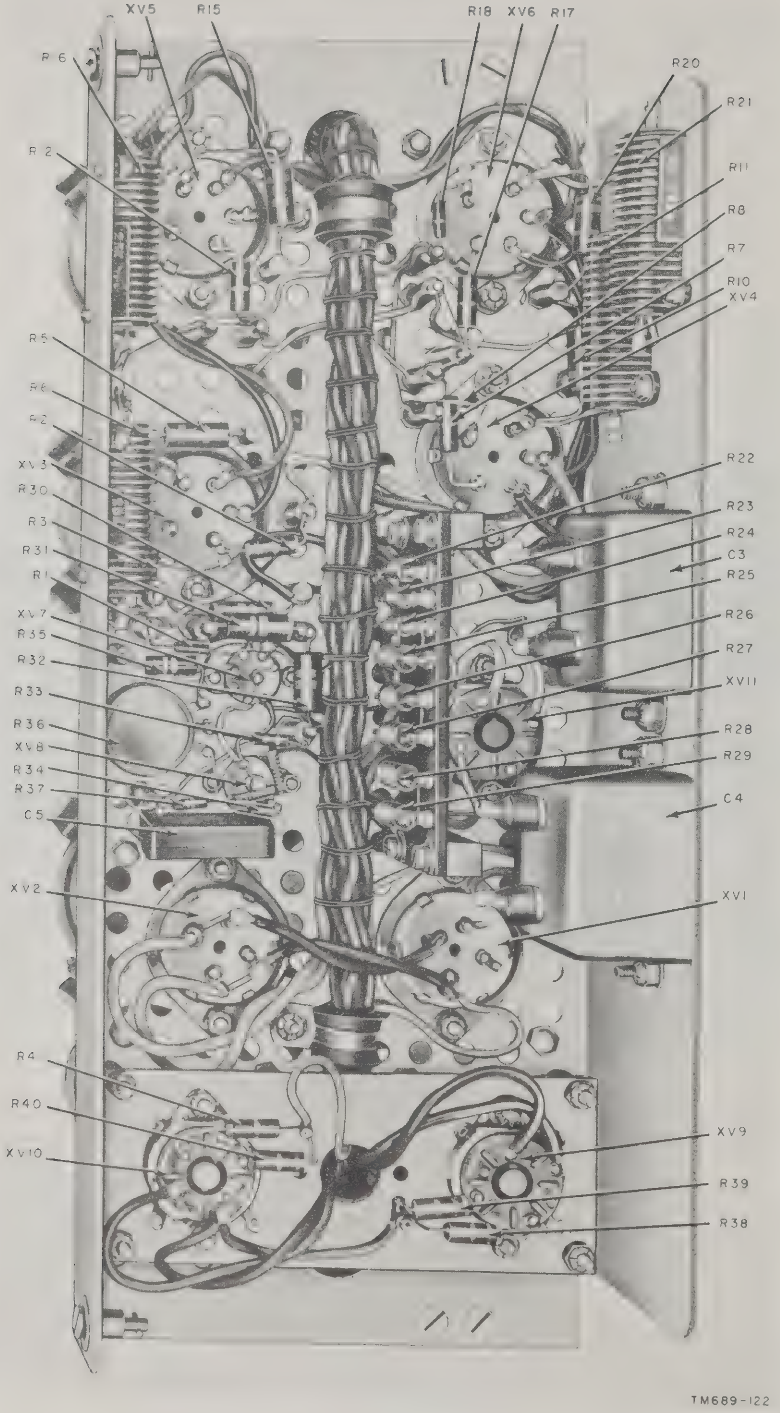

V6
V4
V11
V1
V9
V5
V3
V7
R36
V8
V2
V10
TM689-110

Figure 308. High-voltage power supply, oblique top view.


XV5
R15
R18
XV6
R17
R20
R21
R6
R2
R11
R8
R7
R10
XV4
R5
R6
R2
XV3
R30
R3
R31
R1
XV7
R35
R32
R33
R36
XV8
R34
R37
C5
R22
R23
R24
C3
R25
R26
R27
XV11
R28
R29
C4
XV2
XV1
R4
R40
XV10
XV9
R39
R38

TM689-122

Figure 309. High-voltage power supply, bottom view.

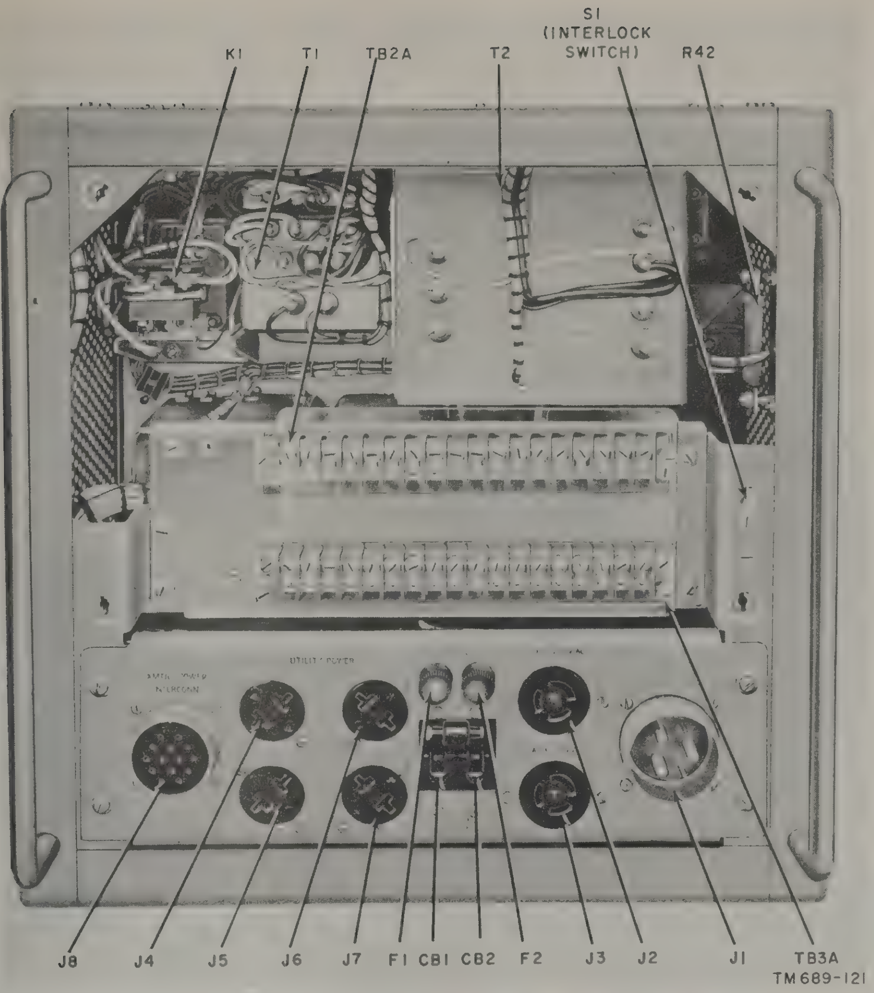

K1
T1
TB2A
T2
S1
(INTERLOCK
SWITCH)
R42
J8
J4
J5
J6
J7
F1
CB1
CB2
F2
J3
J2
J1
TB3A
TM689-121

Figure 310. High-voltage power supply, rear view, cover removed.

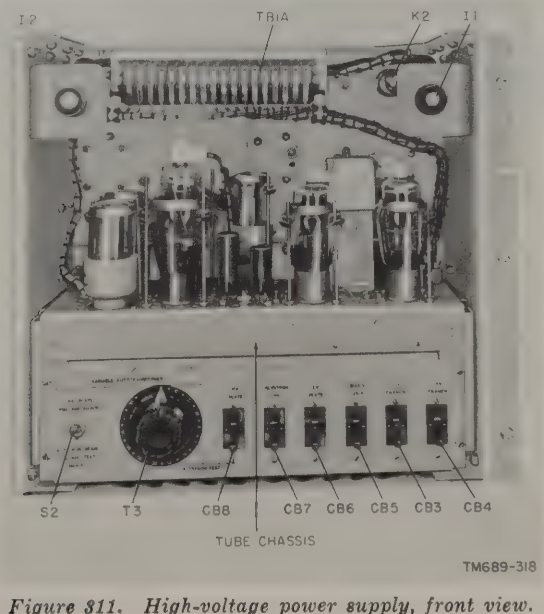

I2
TB1A
K2
I1
S2
T3
CB8
CB7
CB6
CB5
CB3
CB4
TUBE CHASSIS
TM689-318

Figure 311. High-voltage power supply, front view.

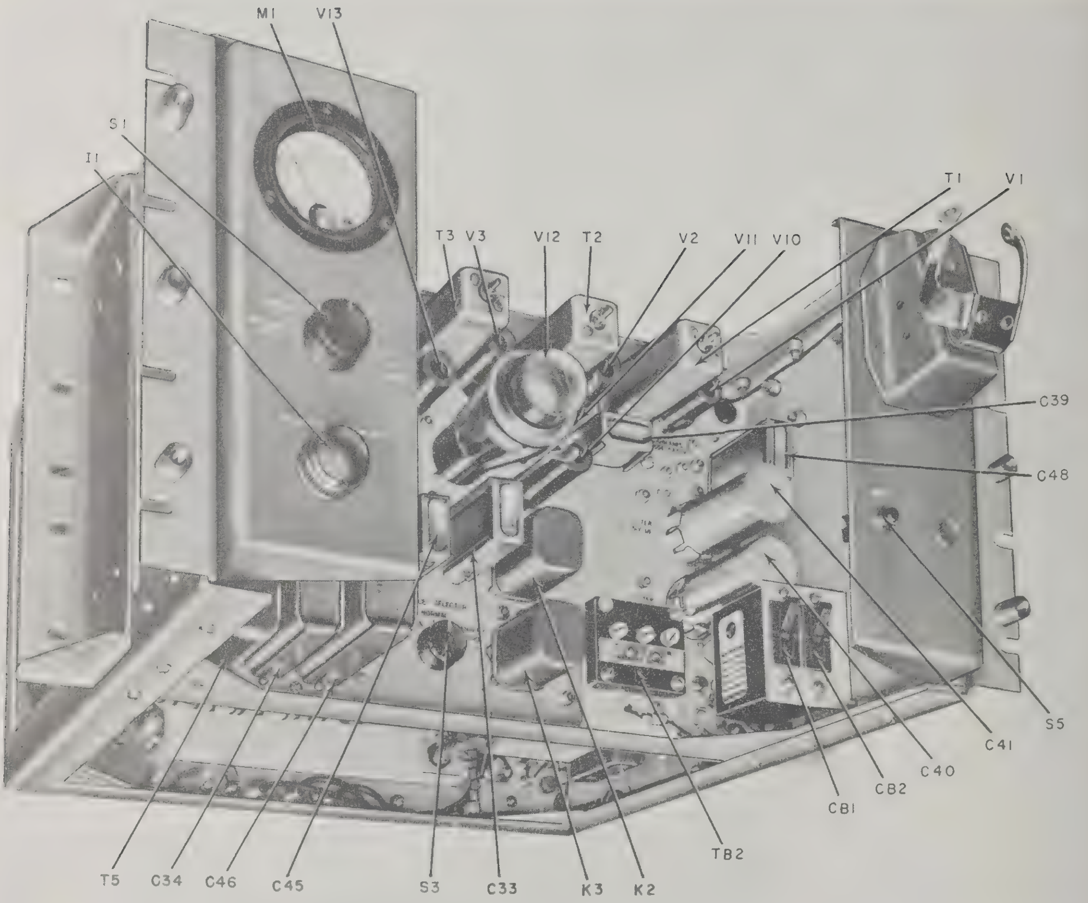

M1
V13
S1
I1
T3
V3
V12
T2
V2
V11
V10
T1
V1
C39
C48
S5
C41
C40
CB2
CB1
TB2
T5
C34
C46
C45
S3
C33
K3
K2
TM689-341

Figure 312. Order-wire receiver, left hand front view.

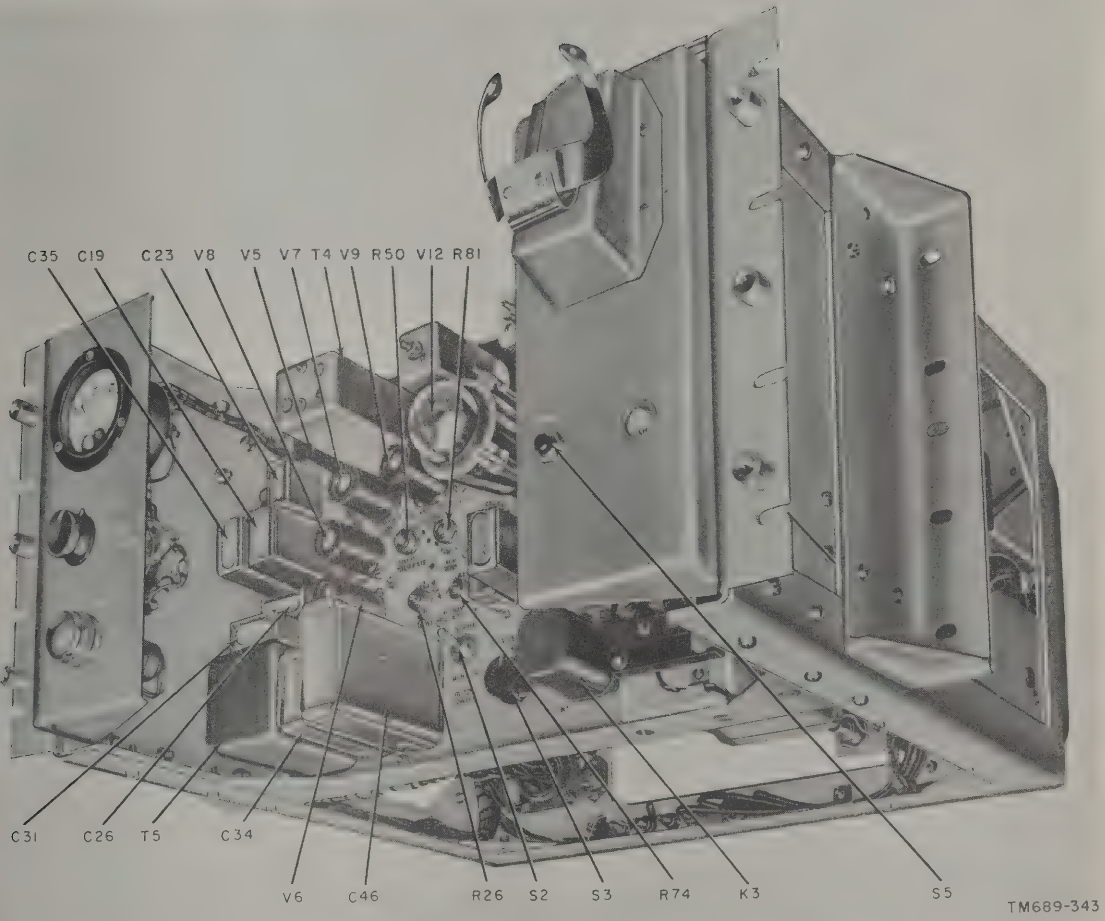

C35
C19
C23
V8
V5
V7
T4
V9
R50
V12
R81
C31
C26
T5
C34
V6
C46
R26
S2
S3
R74
K3
S5
TM689-343

Figure 313. Order-wire receiver, right hand front view.

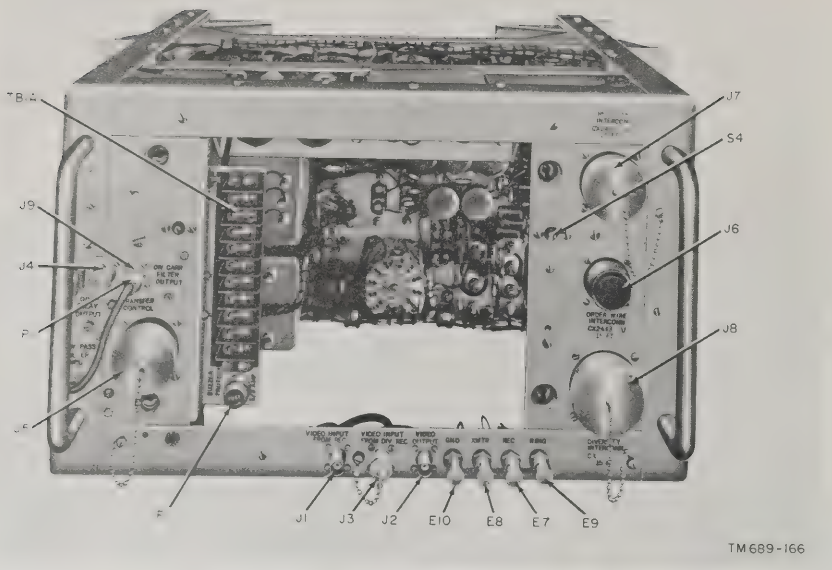

TB4
J9
J4
P
J5
F
J7
S4
J6
J8
VIDEO INPUT FROM REC
VIDEO INPUT FROM DIV REC
VIDEO OUTPUT
GND
XMTR
REC
RING
ORDER WIRE INTERCONN
J1
J3
J2
E10
E8
E7
E9
TM689-166

Figure 314. Order-wire receiver, rear view.

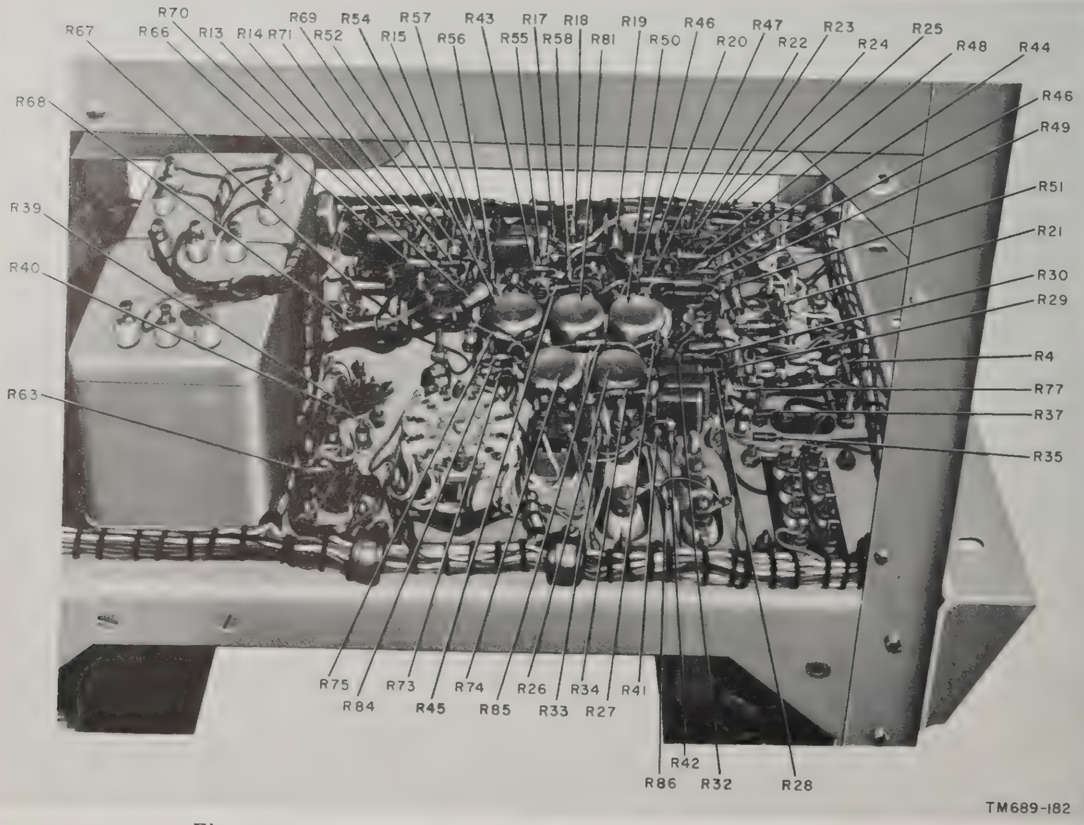

R70
R67
R66
R13
R14
R71
R69
R54
R52
R57
R15
R56
R43
R17
R55
R58
R18
R81
R19
R50
R46
R20
R47
R22
R23
R24
R25
R48
R44
R68
R46
R49
R51
R21
R39
R30
R40
R29
R4
R77
R37
R63
R35
R75
R84
R73
R45
R74
R85
R26
R33
R34
R27
R41
R42
R86
R32
R28
TM689-182

Figure 315. Order-wire receiver, rear oblique view showing resistors.

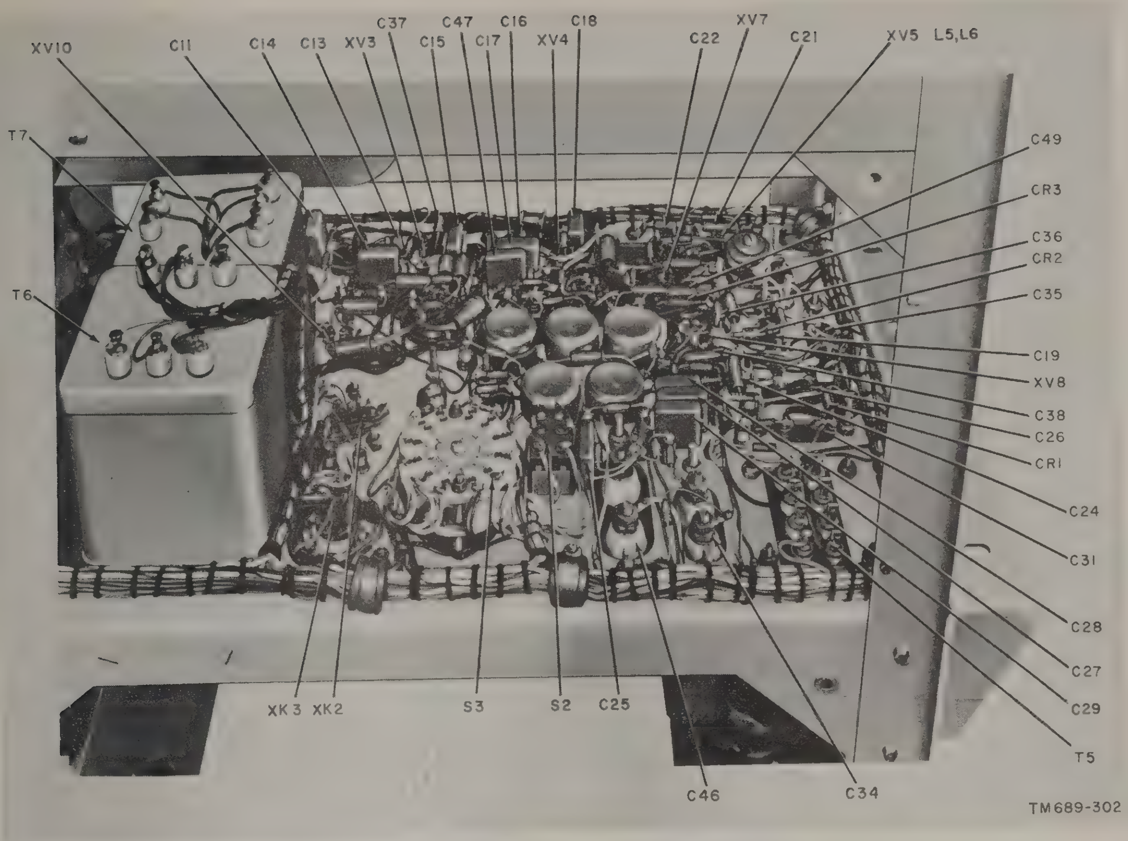

XV10
C11
C14
C13
XV3
C37
C15
C47
C17
C16
XV4
C18
C22
XV7
C21
XV5
L5,L6
T7
T6
C49
CR3
C36
CR2
C35
C19
XV8
C38
C26
CR1
C24
C31
C28
C27
C29
T5
XK3
XK2
S3
S2
C25
C46
C34
TM689-302

Figure 316. Order-wire receiver, oblique view of rear.

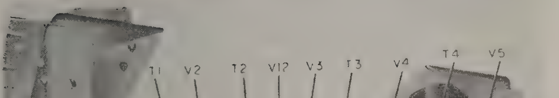

T1
V2
T2
V12
V3
T3
V4
T4
V5
C43
C42
C44
TM689-86

Figure 317. Order-wire receiver, top view.

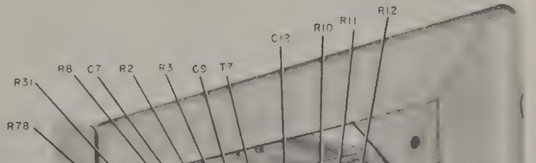
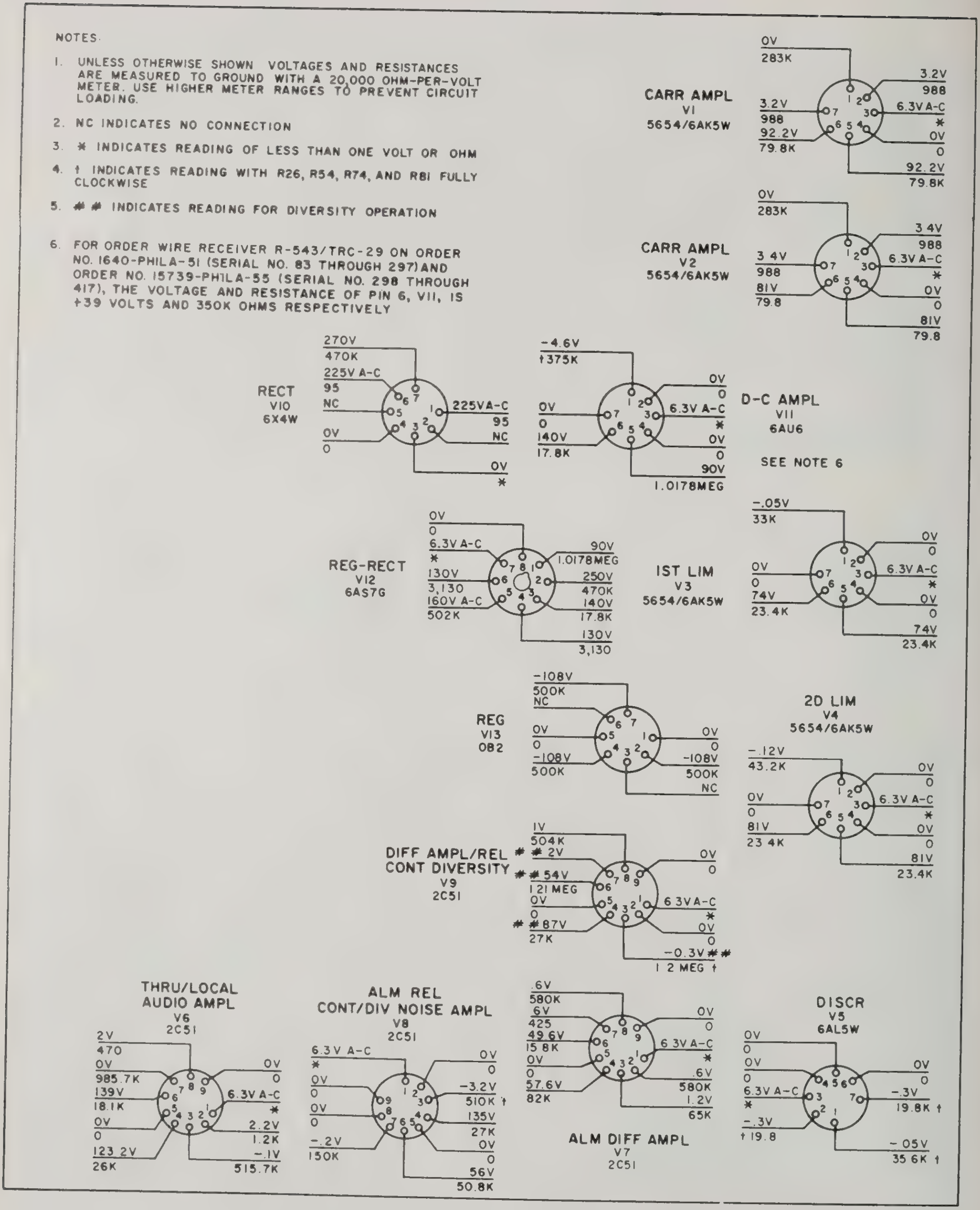

R31
R8
C7
R2
R3
C9
T7
C12
R10
R11
R12
R78
R79
R6
C48
C32
R82
R83
R64
R65
XC41
CR5
XC40
R61
CR4
TM689-196

Figure 318. Order-wire receiver, side view.

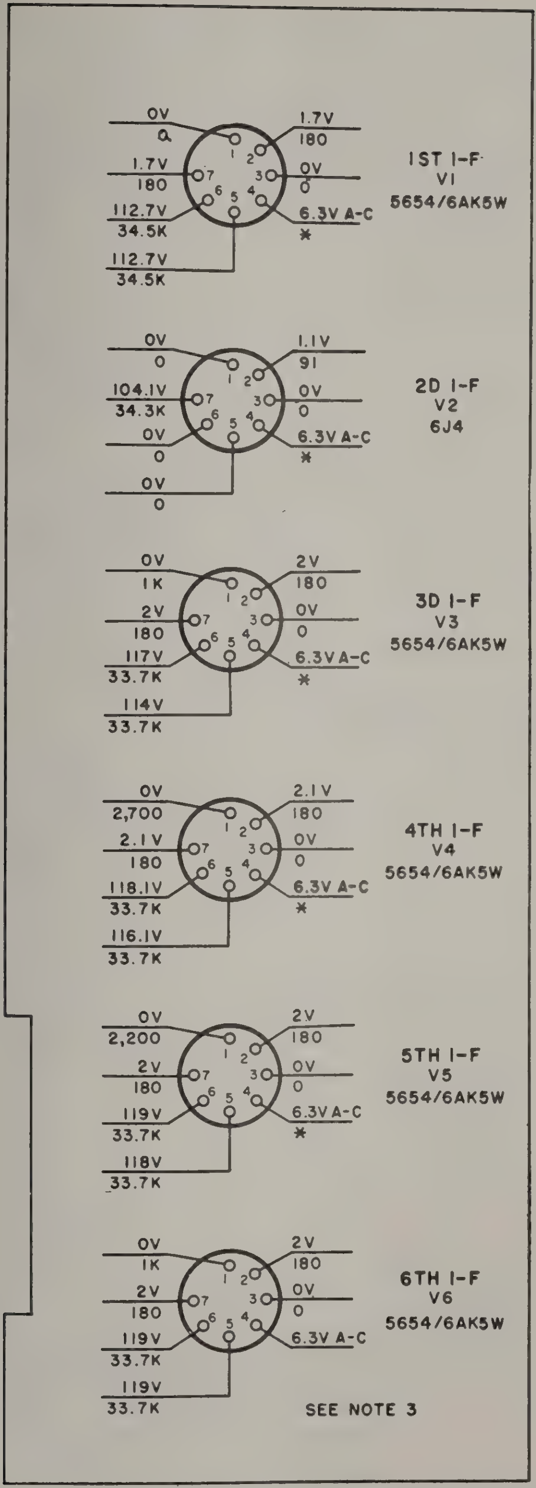


NOTES:

1. UNLESS OTHERWISE SHOWN VOLTAGES AND RESISTANCES ARE MEASURED TO GROUND WITH A 20,000 OHM-PER-VOLT METER. USE HIGHER METER RANGES TO PREVENT CIRCUIT LOADING.
2. NC INDICATES NO CONNECTION
3. * INDICATES READING OF LESS THAN ONE VOLT OR OHM
4. † INDICATES READING WITH R26, R54, R74, AND R81 FULLY CLOCKWISE
5. # # INDICATES READING FOR DIVERSITY OPERATION
6. FOR ORDER WIRE RECEIVER R-543/TRC-29 ON ORDER NO. 1640-PHILA-51 (SERIAL NO. 83 THROUGH 297) AND ORDER NO. 15739-PHILA-55 (SERIAL NO. 298 THROUGH 417), THE VOLTAGE AND RESISTANCE OF PIN 6, V11, IS +39 VOLTS AND 350K OHMS RESPECTIVELY

CARR AMPL
V1
5654/6AK5W
0V
283K
3.2V
988
6.3V A-C
*
0V
0
92.2V
79.8K
3.2V
988
92.2V
79.8K
CARR AMPL
V2
5654/6AK5W
0V
283K
3.4V
988
6.3V A-C
*
0V
0
81V
79.8
3.4V
988
81V
79.8
RECT
V10
6X4W
270V
470K
225V A-C
95
NC
0V
0
225VA-C
95
NC
0V
*
D-C AMPL
V11
6AU6
SEE NOTE 6
-4.6V
†375K
0V
0
140V
17.8K
0V
0
6.3V A-C
*
0V
0
90V
1.0178MEG
REG-RECT
V12
6AS7G
0V
0
6.3V A-C
*
130V
3,130
160V A-C
502K
90V
1.0178MEG
250V
470K
140V
17.8K
130V
3,130
1ST LIM
V3
5654/6AK5W
-.05V
33K
0V
0
74V
23.4K
0V
0
6.3V A-C
*
0V
0
74V
23.4K
REG
V13
OB2
-108V
500K
NC
0V
0
-108V
500K
0V
0
-108V
500K
NC
2D LIM
V4
5654/6AK5W
-.12V
43.2K
0V
0
81V
23.4K
0V
0
6.3V A-C
*
0V
0
81V
23.4K
DIFF AMPL/REL
CONT DIVERSITY
V9
2C51
1V
504K
# 2V
# 54V
1.21 MEG
0V
0
# 87V
27K
0V
0
6.3V A-C
*
0V
0
-0.3V # #
1.2 MEG †
THRU/LOCAL
AUDIO AMPL
V6
2C51
2V
470
0V
985.7K
139V
18.1K
0V
0
123.2V
26K
0V
0
6.3V A-C
*
2.2V
1.2K
-.1V
515.7K
ALM REL
CONT/DIV NOISE AMPL
V8
2C51
6.3V A-C
*
0V
0
0V
0
-.2V
150K
0V
0
-3.2V
510K †
135V
27K
0V
0
56V
50.8K
ALM DIFF AMPL
V7
2C51
.6V
580K
.6V
425
49.6V
15.8K
0V
0
57.6V
82K
0V
0
6.3V A-C
*
.6V
580K
1.2V
65K
DISCR
V5
6AL5W
0V
0
0V
0
6.3V A-C
*
-.3V
†19.8
0V
0
-.3V
19.8K †
-.05V
35.6K †
TM689-469

Figure 319. Order-wire receiver, tube socket voltage and resistance diagram.

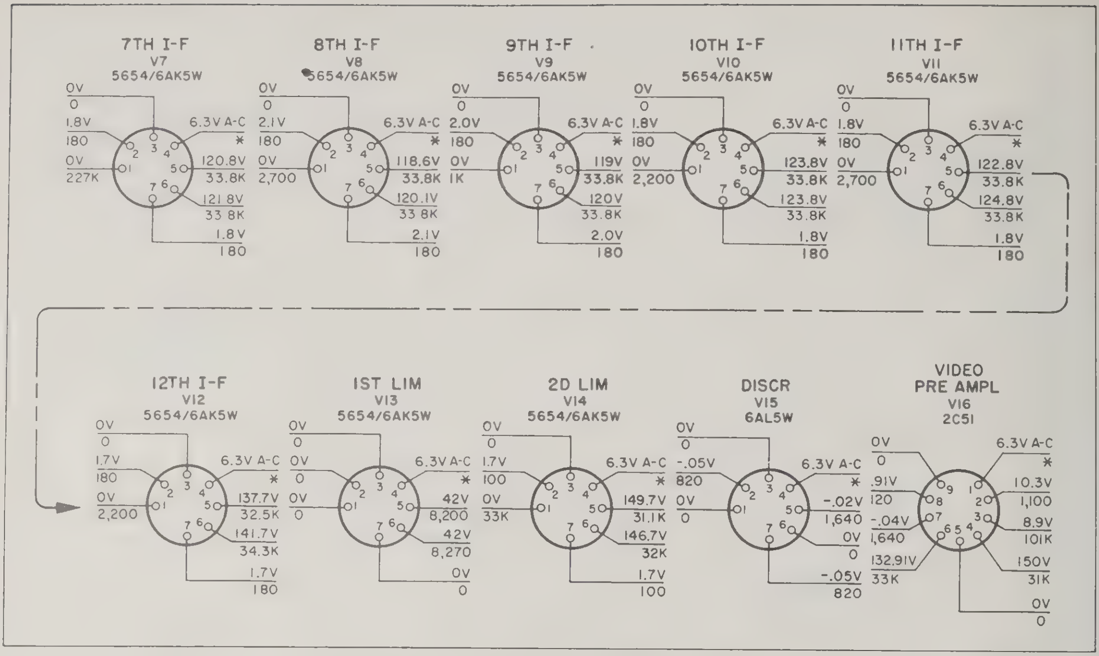

0V
a
1.7V
180
1.7V
180
0V
0
112.7V
34.5K
6.3V A-C
*
112.7V
34.5K
1ST I-F
V1
5654/6AK5W
0V
0
1.1V
91
104.1V
34.3K
0V
0
0V
0
6.3V A-C
*
0V
0
2D I-F
V2
6J4
0V
1K
2V
180
2V
180
0V
0
117V
33.7K
6.3V A-C
*
114V
33.7K
3D I-F
V3
5654/6AK5W
0V
2,700
2.1V
180
2.1V
180
0V
0
118.1V
33.7K
6.3V A-C
*
116.1V
33.7K
4TH I-F
V4
5654/6AK5W
0V
2,200
2V
180
2V
180
0V
0
119V
33.7K
6.3V A-C
*
118V
33.7K
5TH I-F
V5
5654/6AK5W
0V
1K
2V
180
2V
180
0V
0
119V
33.7K
6.3V A-C
119V
33.7K
6TH I-F
V6
5654/6AK5W
SEE NOTE 3

NOTES.

1. UNLESS OTHERWISE SHOWN VOLTAGES AND RESISTANCES ARE MEASURED TO GROUND WITH A 20,000 OHM-PER-VOLT METER. USE HIGHER METER RANGES TO PREVENT CIRCUIT LOADING.
2. * INDICATES READING OF LESS THAN 1 VOLT OR OHM.
3. FOR RADIO RECEIVER R-418/G ON ORDER NO. 1640-PHILA-51 (SERIAL NO. 16 THROUGH 297) AND ORDER NO. 15739 (SERIAL NO. 298 THROUGH 417), THE RESISTANCE OF PIN 1, V6, IS 2.2K OHMS.

TM689-460

Figure 320. If. preamplifier, tube socket voltage and resistance diagram.


7TH I-F
V7
5654/6AK5W
0V
0
1.8V
180
0V
227K
6.3V A-C
*
120.8V
33.8K
121.8V
33.8K
1.8V
180
8TH I-F
V8
5654/6AK5W
0V
0
2.1V
180
0V
2,700
6.3V A-C
*
118.6V
33.8K
120.1V
33.8K
2.1V
180
9TH I-F
V9
5654/6AK5W
0V
0
2.0V
180
0V
1K
6.3V A-C
*
119V
33.8K
120V
33.8K
2.0V
180
10TH I-F
V10
5654/6AK5W
0V
0
1.8V
180
0V
2,200
6.3V A-C
*
123.8V
33.8K
123.8V
33.8K
1.8V
180
11TH I-F
V11
5654/6AK5W
0V
0
1.8V
180
0V
2,700
6.3V A-C
*
122.8V
33.8K
124.8V
33.8K
1.8V
180
12TH I-F
V12
5654/6AK5W
0V
0
1.7V
180
0V
2,200
6.3V A-C
*
137.7V
32.5K
141.7V
34.3K
1.7V
180
1ST LIM
V13
5654/6AK5W
0V
0
0V
0
0V
0
6.3V A-C
*
42V
8,200
42V
8,270
0V
0
2D LIM
V14
5654/6AK5W
0V
0
1.7V
100
0V
33K
6.3V A-C
*
149.7V
31.1K
146.7V
32K
1.7V
100
DISCR
V15
6AL5W
0V
0
-.05V
820
0V
0
6.3V A-C
*
-.02V
1,640
0V
0
-.05V
820
VIDEO
PRE AMPL
V16
2C51
0V
0
.91V
120
-.04V
1,640
132.91V
33K
6.3V A-C
*
10.3V
1,100
8.9V
101K
150V
31K
0V
0

NOTES:

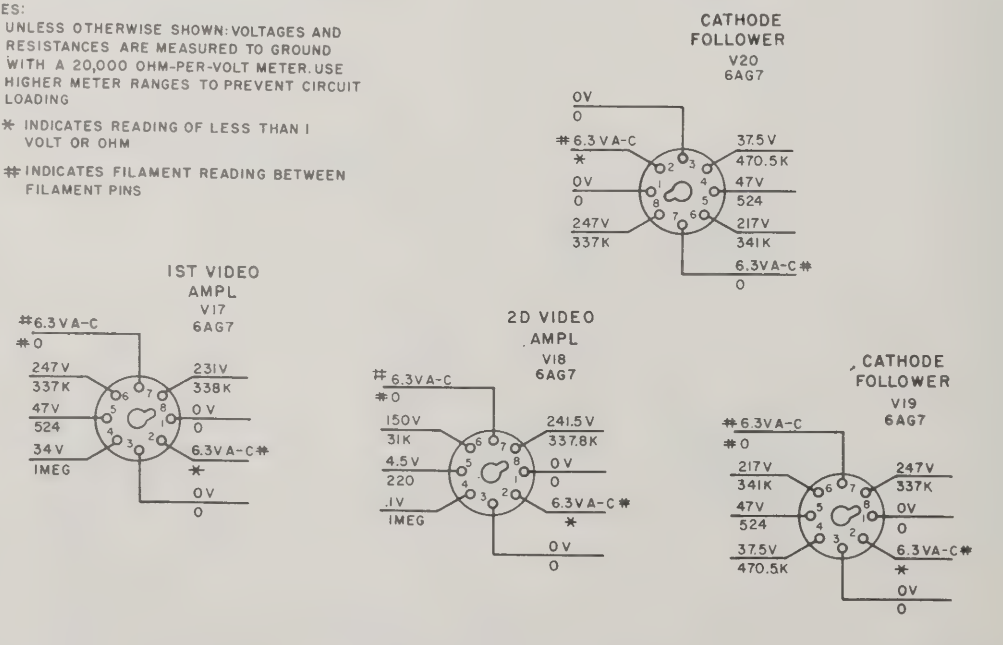
1. UNLESS OTHERWISE SHOWN: VOLTAGES AND RESISTANCES ARE MEASURED TO GROUND WITH A 20,000 OHM-PER-VOLT METER. USE HIGHER METER RANGES TO PREVENT CIRCUIT LOADING
2. * INDICATES READING OF LESS THAN 1 VOLT OR OHM

TM689-459

Figure 321. If. amplifier, tube socket voltage and resistance diagram.

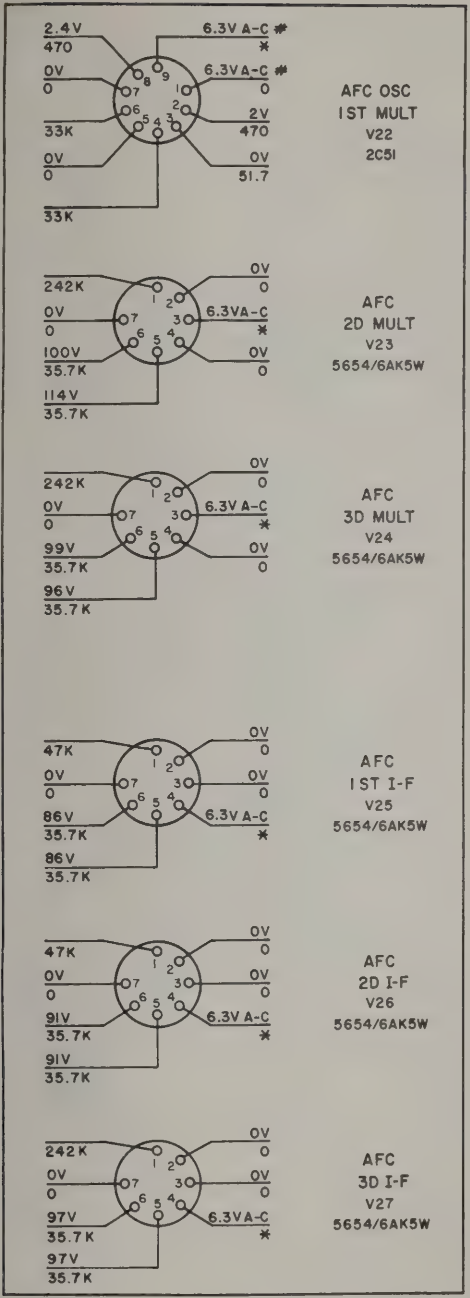
NOTES:

1. UNLESS OTHERWISE SHOWN: VOLTAGES AND RESISTANCES ARE MEASURED TO GROUND WITH A 20,000 OHM-PER-VOLT METER. USE HIGHER METER RANGES TO PREVENT CIRCUIT LOADING
2. * INDICATES READING OF LESS THAN 1 VOLT OR OHM
3. # INDICATES FILAMENT READING BETWEEN FILAMENT PINS


CATHODE
FOLLOWER
V20
6AG7
0V
0
# 6.3V A-C
*
0V
0
247V
337K
37.5V
470.5K
47V
524
217V
341K
6.3VA-C #
0
1ST VIDEO
AMPL
V17
6AG7
#6.3V A-C
#0
247V
337K
47V
524
34V
1MEG
231V
338K
0V
0
6.3V A-C #
*
0V
0
2D VIDEO
AMPL
V18
6AG7
# 6.3V A-C
#0
150V
31K
4.5V
220
.1V
1MEG
241.5V
337.8K
0V
0
6.3V A-C #
*
0V
0
CATHODE
FOLLOWER
V19
6AG7
# 6.3V A-C
#0
217V
341K
47V
524
37.5V
470.5K
247V
337K
0V
0
6.3VA-C #
*
0V
0

TM689-462

Figure 322. Video amplifier, tube socket voltage and resistance diagram.

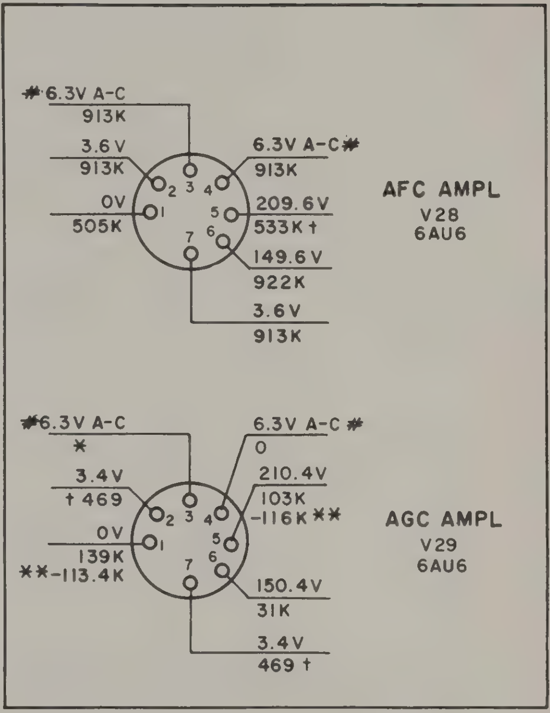

2.4V
470
6.3V A-C #
*
0V
0
6.3VA-C #
0
2V
470
33K
0V
0
0V
51.7
33K
AFC OSC
1ST MULT
V22
2C51
242K
0V
0
6.3VA-C
*
100V
35.7K
0V
0
114V
35.7K
AFC
2D MULT
V23
5654/6AK5W
242K
0V
0
0V
0
6.3V A-C
*
99V
35.7K
0V
0
96V
35.7K
AFC
3D MULT
V24
5654/6AK5W
47K
0V
0
0V
0
0V
0
86V
35.7K
6.3V A-C
*
86V
35.7K
AFC
1ST I-F
V25
5654/6AK5W
47K
0V
0
0V
0
0V
0
91V
35.7K
6.3V A-C
*
91V
35.7K
AFC
2D I-F
V26
5654/6AK5W
242K
0V
0
0V
0
0V
0
97V
35.7K
6.3VA-C
*
97V
35.7K
AFC
3D I-F
V27
5654/6AK5W

NOTES:

1. UNLESS OTHERWISE SHOWN: VOLTAGES AND RESISTANCES ARE MEASURED TO GROUND WITH A 20,000 OHM-PER-VOLT METER. USE HIGHER METER RANGES TO PREVENT CIRCUIT LOADING.
2. * INDICATES READING OF LESS THAN 1 VOLT OR OHM.
3. # INDICATES FILAMENT READING BETWEEN FILAMENT PINS.

TM689-461

Figure 323. Afc circuits, tube socket voltage and resistance diagram.

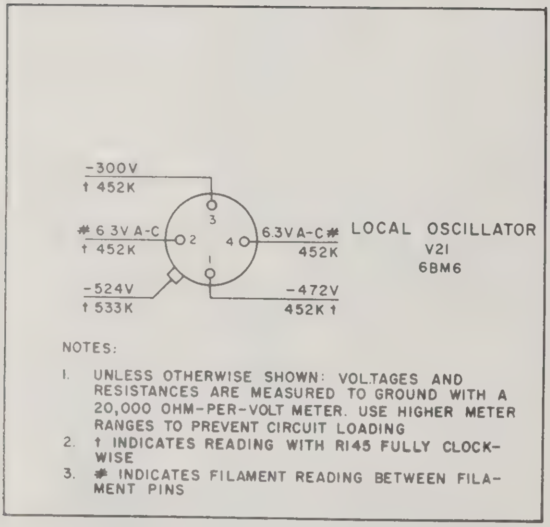

#6.3V A-C
913K
3.6V
913K
0V
505K
6.3V A-C#
913K
209.6V
533K †
149.6V
922K
3.6V
913K
AFC AMPL
V28
6AU6
#6.3V A-C
*
3.4V
† 469
0V
139K
**-113.4K
6.3V A-C #
0
210.4V
103K
-116K **
150.4V
31K
3.4V
469 †
AGC AMPL
V29
6AU6

NOTES:

1. UNLESS OTHERWISE SHOWN: VOLTAGES AND RESISTANCES ARE MEASURED TO GROUND WITH A 20,000 OHM-PER-VOLT METER. USE HIGHER METER RANGES TO PREVENT CIRCUIT LOADING.
2. * INDICATES READING OF LESS THAN 1 VOLT OR OHM
3. ** INDICATES READING WITH METER LEADS REVERSED
4. † INDICATES READING WITH R116 AND R152 FULLY CLOCKWISE
5. # INDICATES FILAMENT READING BETWEEN FILAMENT PINS

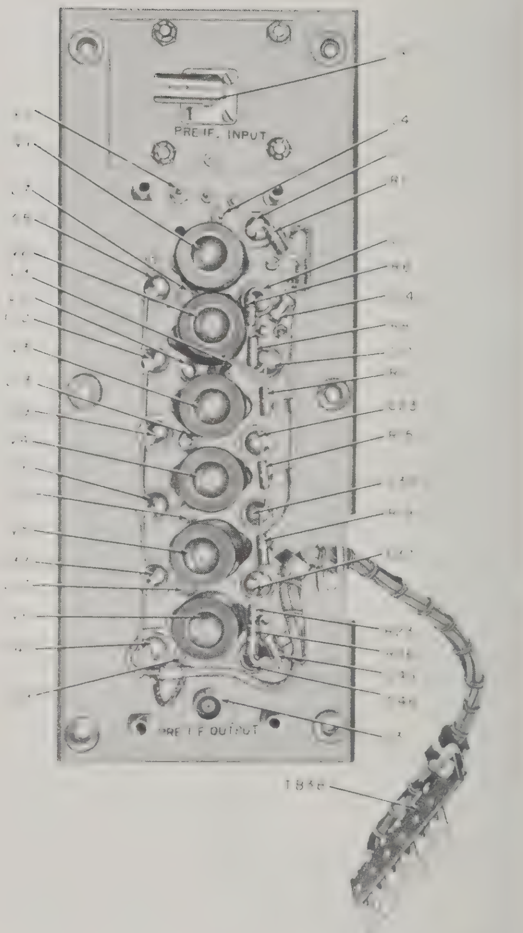
TM689-463

Figure 324. Agc and afc dc amplifiers, tube socket voltage and resistance diagram.


-300V
† 452K
3
# 6.3V A-C
2
† 452K
4
6.3VA-C #
452K
LOCAL OSCILLATOR
V21
6BM6
1
-524V
† 533K
-472V
452K †
NOTES:
1. UNLESS OTHERWISE SHOWN: VOLTAGES AND RESISTANCES ARE MEASURED TO GROUND WITH A 20,000 OHM-PER-VOLT METER. USE HIGHER METER RANGES TO PREVENT CIRCUIT LOADING
2. † INDICATES READING WITH R145 FULLY CLOCKWISE
3. # INDICATES FILAMENT READING BETWEEN FILAMENT PINS

TM689-470

Figure 325. Local oscillator, tube socket and resistance diagram.


PRE IF. INPUT
PRE I F OUTPUT

TM689-169

Figure 326. If. preamplifier, front view.

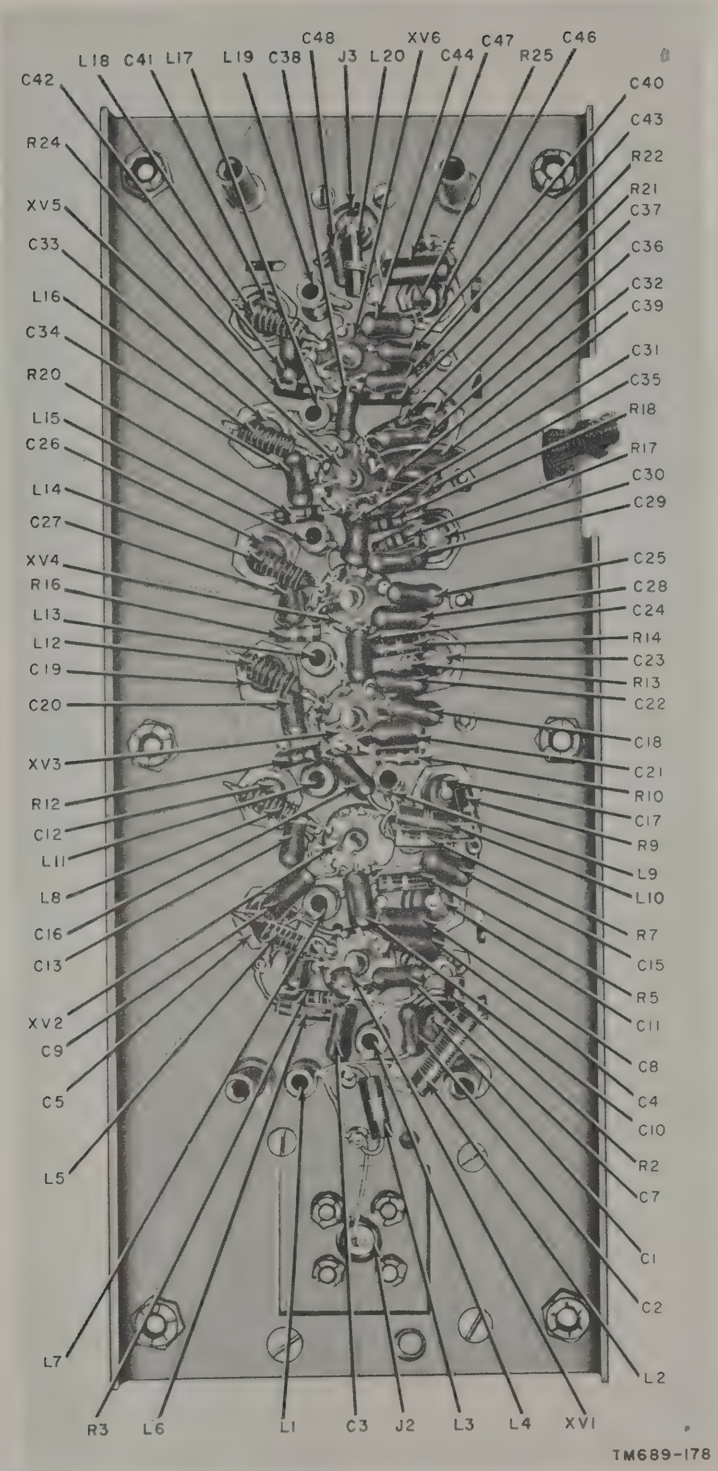

C48
XV6
C47
C46
L18
C41
L17
L19
C38
J3
L20
C44
R25
C42
R24
XV5
C33
L16
C34
R20
L15
C26
L14
C27
XV4
R16
L13
L12
C19
C20
XV3
R12
C12
L11
L8
C16
C13
XV2
C9
C5
L5
L7
C40
C43
R22
R21
C37
C36
C32
C39
C31
C35
R18
R17
C30
C29
C25
C28
C24
R14
C23
R13
C22
C18
C21
R10
C17
R9
L9
L10
R7
C15
R5
C11
C8
C4
C10
R2
C7
C1
C2
L2
R3
L6
L1
C3
J2
L3
L4
XV1
TM689-178

Figure 327. If. preamplifier, rear view.

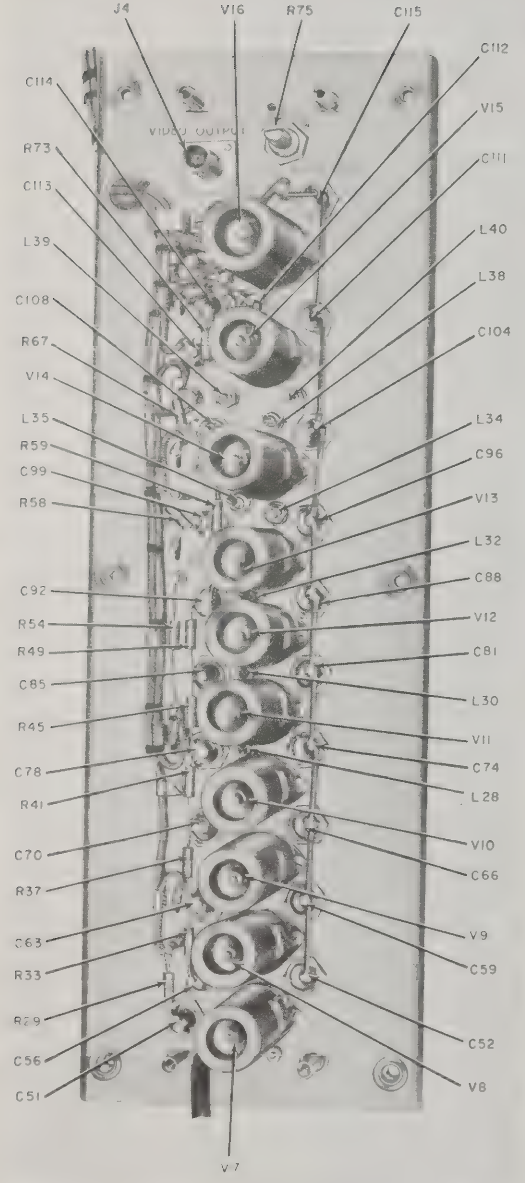

J4
V16
R75
C115
C112
C114
V15
R73
C111
C113
VIDEO OUTPUT
L39
L40
L38
C108
C104
R67
V14
L35
L34
R59
C96
C99
V13
R58
L32
C88
C92
V12
R54
R49
C81
C85
L30
R45
V11
C78
C74
L28
R41
V10
C70
C66
R37
V9
C63
C59
R33
R29
C52
C56
V8
C51
V7
TM689-111

Figure 328. If. amplifier, front view.

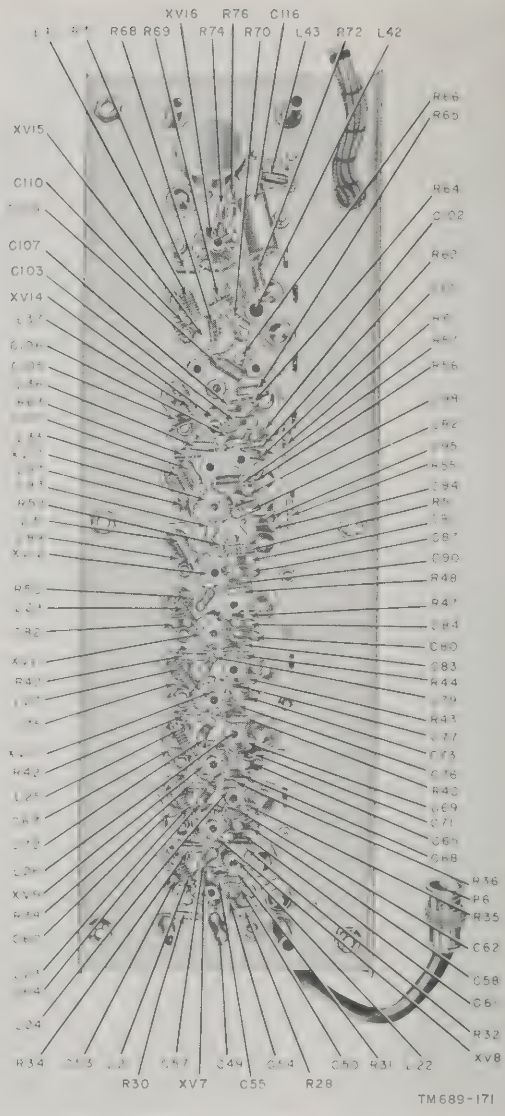

XV16
R76
C116
R68
R69
R74
R70
L43
R72
L42
R66
R65
XV15
C110
R64
C102
C107
R62
C103
XV14
R56
C94
C87
C90
R48
R47
C84
C80
C83
R44
R43
C76
R42
R40
C69
C71
C65
C68
R36
P6
R35
C62
C58
L24
R32
R34
XV8
R30
XV7
C49
C55
R28
R31
L22
TM689-171

Figure 329. If. amplifier, rear view.

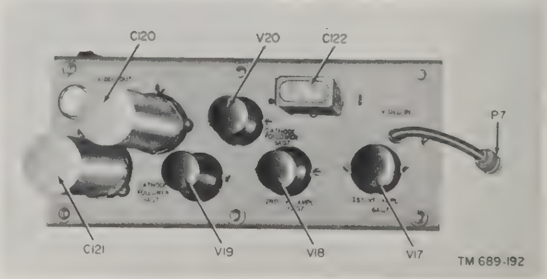

C120
V20
C122
P7
C121
V19
V18
V17
TM 689-192

Figure 330. Video amplifier, front view.

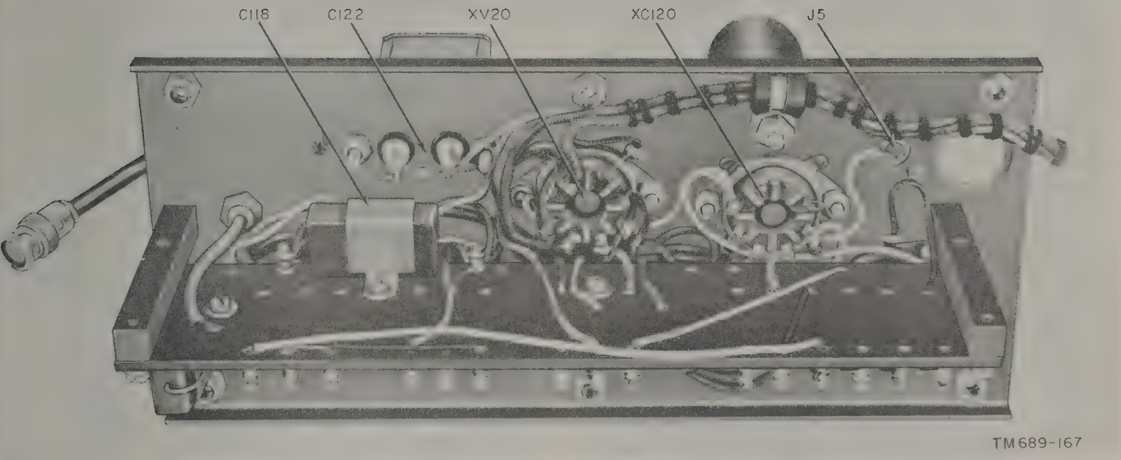

C118
C122
XV20
XC120
J5
TM689-167

Figure 331. Video amplifier, rear view, right oblique.

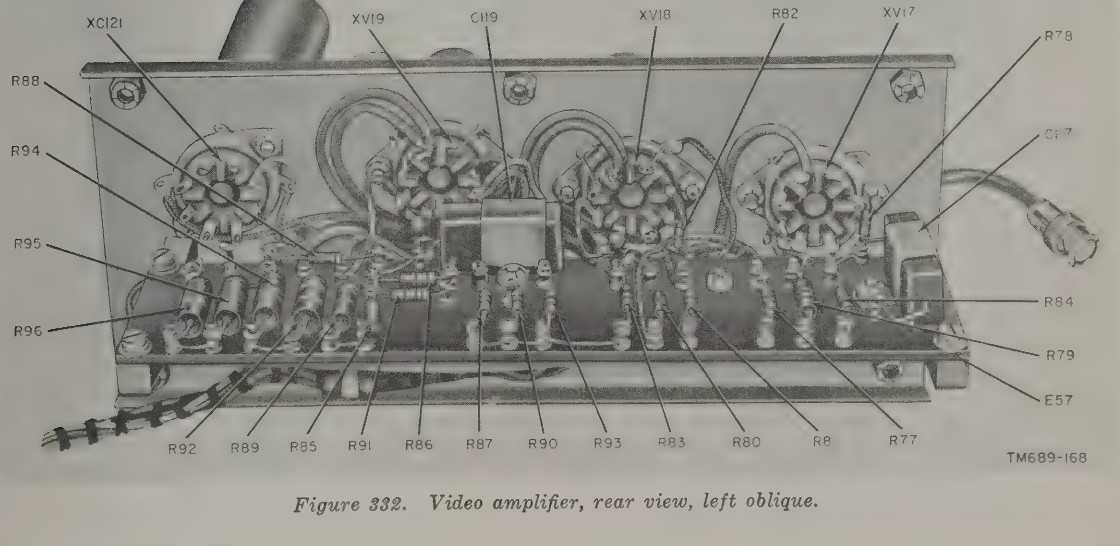

XC121
XV19
C119
XV18
R82
XV17
R78
R88
R94
C117
R95
R96
R84
R79
E57
R92
R89
R85
R91
R86
R87
R90
R93
R83
R80
R8
R77
TM689-168

Figure 332. Video amplifier, rear view, left oblique.

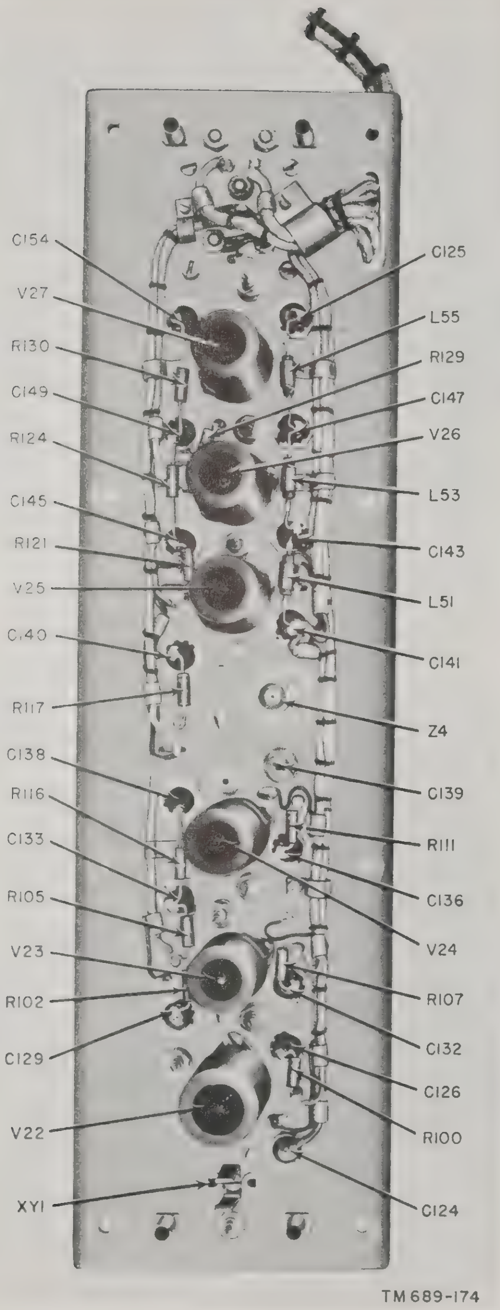

C154
V27
R130
C149
R124
C145
R121
V25
C140
R117
C138
R116
C133
R105
V23
R102
C129
V22
XY1
C125
L55
R129
C147
V26
L53
C143
L51
C141
Z4
C139
R111
C136
V24
R107
C132
C126
R100
C124
TM689-174

Figure 333. Afc circuits, front view.

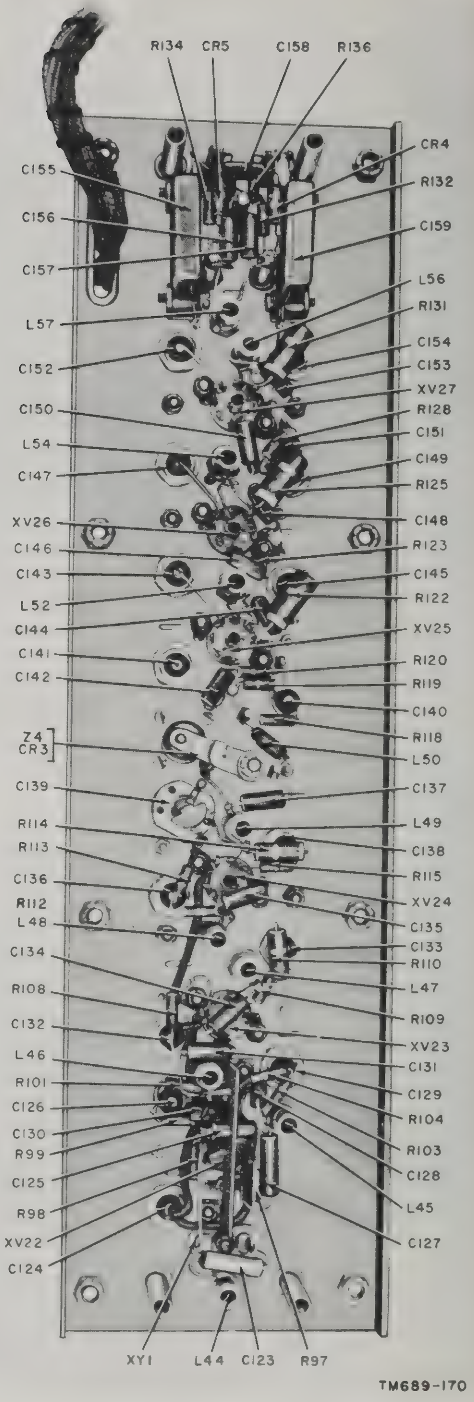

R134
CR5
C158
R136
C155
C156
C157
L57
C152
C150
L54
C147
XV26
C146
C143
L52
C144
C141
C142
Z4
CR3
C139
R114
R113
C136
R112
L48
C134
R108
C132
L46
R101
C126
C130
R99
C125
R98
XV22
C124
CR4
R132
C159
L56
R131
C154
C153
XV27
R128
C151
C149
R125
C148
R123
C145
R122
XV25
R120
R119
C140
R118
L50
C137
L49
C138
R115
XV24
C135
C133
R110
L47
R109
XV23
C131
C129
R104
R103
C128
L45
C127
XY1
L44
C123
R97
TM689-170

Figure 334. Afc circuits, rear view.

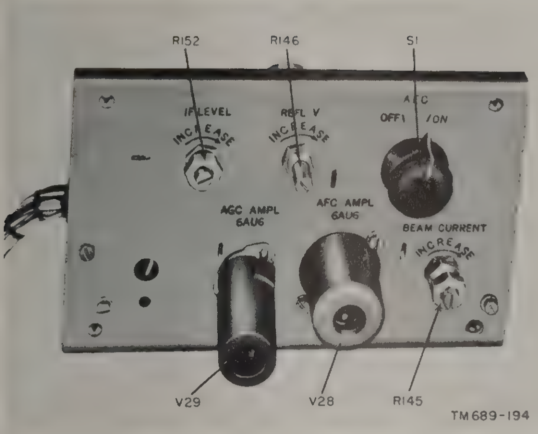

R152
R146
S1
IF LEVEL
INCREASE
REFL V
INCREASE
AFC
OFF
ON
AGC AMPL
6AU6
AFC AMPL
6AU6
BEAM CURRENT
INCREASE
V29
V28
R145
TM689-194

Figure 335. Agc and afc dc amplifiers, front view.

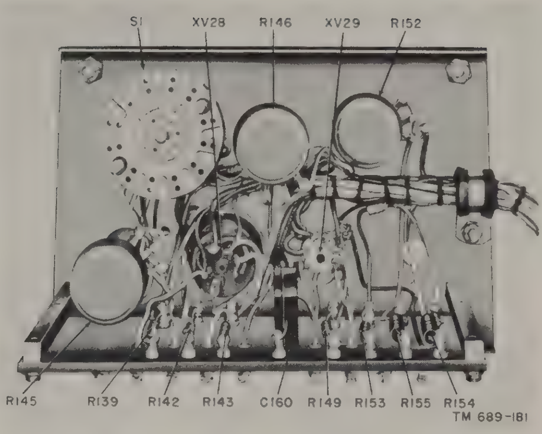

S1
XV28
R146
XV29
R152
R145
R139
R142
R143
C160
R149
R153
R155
R154
TM 689-181

Figure 336. Agc and afc dc amplifiers, rear view.

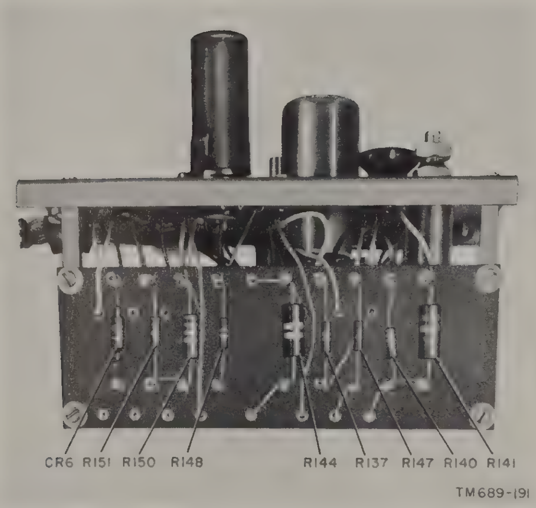
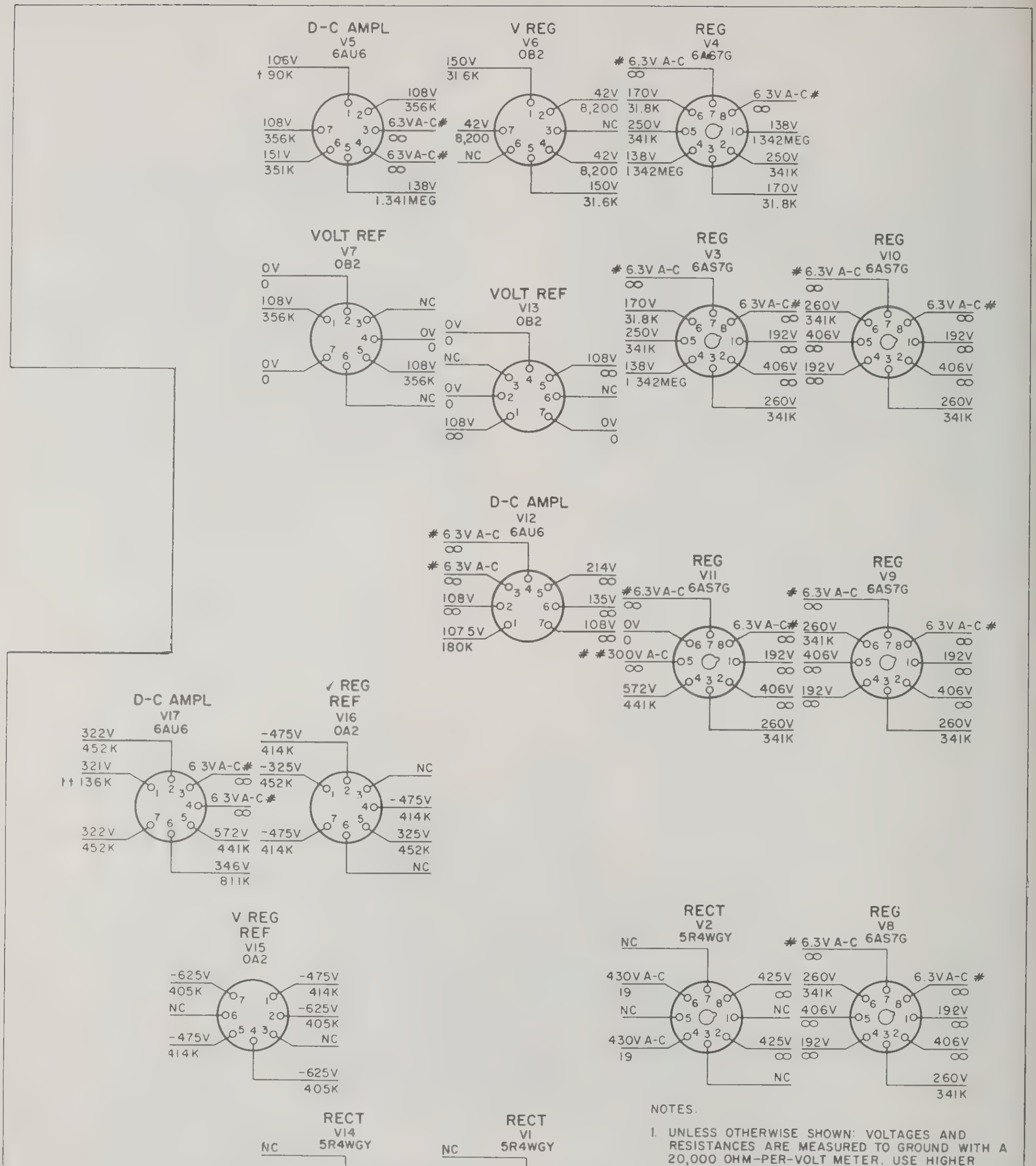

CR6
R151
R150
R148
R144
R137
R147
R140
R141
TM689-191

Figure 337. Agc and afc dc amplifiers, side view.

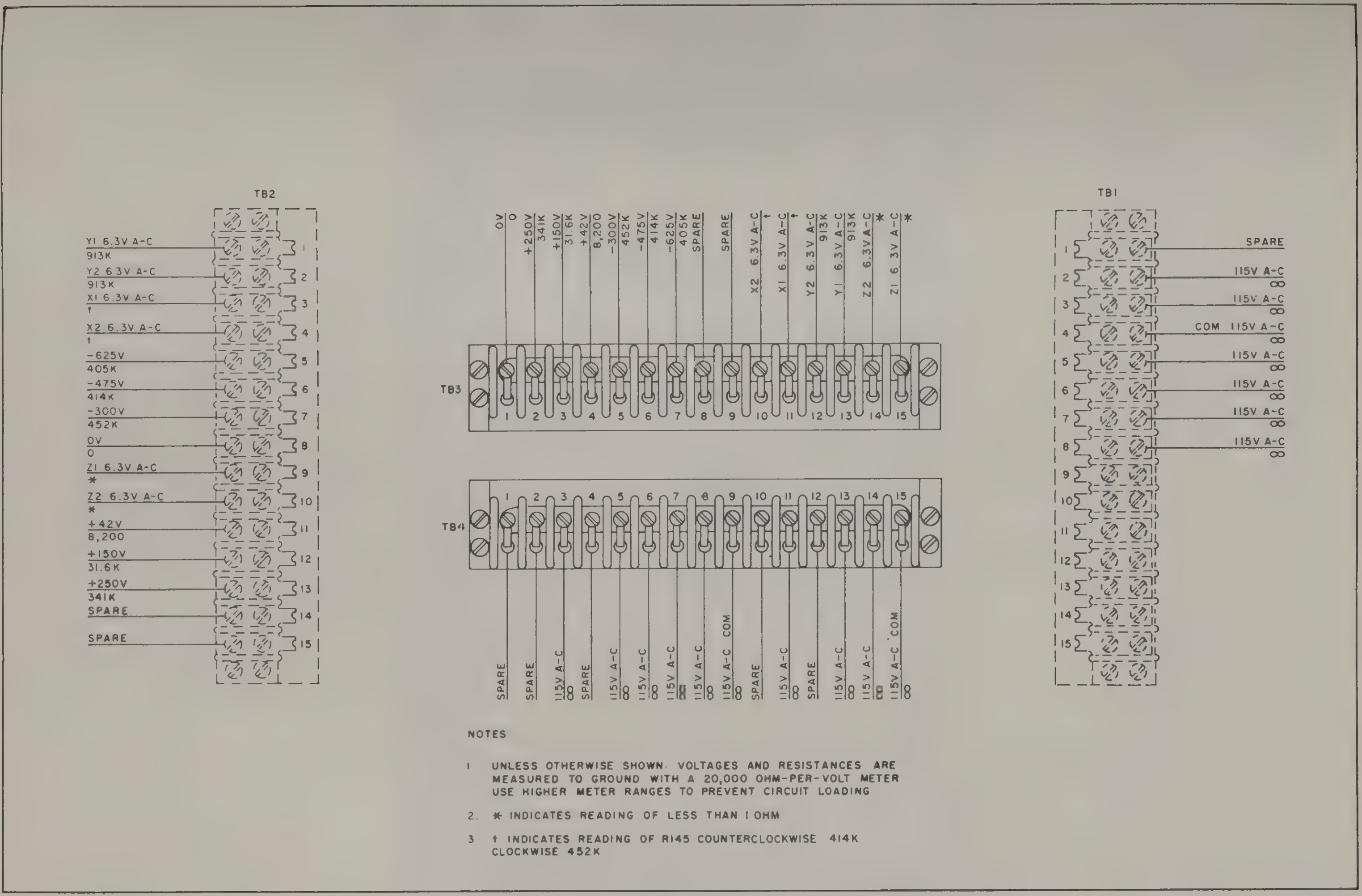

D-C AMPL
V5
6AU6
106V
† 90K
108V
356K
6.3VA-C#
∞
151V
351K
138V
1.341MEG
V REG
V6
0B2
150V
31.6K
42V
8,200
NC
REG
V4
6AS7G
# 6.3V A-C
170V
31.8K
250V
341K
138V
1342MEG
VOLT REF
V7
0B2
0V
0
VOLT REF
V13
0B2
REG
V3
6AS7G
REG
V10
6AS7G
260V
406V
192V
D-C AMPL
V12
6AU6
214V
135V
107.5V
180K
REG
V11
6AS7G
# #300V A-C
572V
441K
REG
V9
6AS7G
D-C AMPL
V17
6AU6
322V
452K
321V
†† 136K
346V
811K
V REG
REF
V16
0A2
-475V
414K
-325V
452K
325V
V REG
REF
V15
0A2
-625V
405K
RECT
V2
5R4WGY
430V A-C
19
425V
REG
V8
6AS7G
RECT
V14
5R4WGY
#✱ 300V A-C
405.5K
RECT
V1
5R4WGY

NOTES.

1. UNLESS OTHERWISE SHOWN: VOLTAGES AND RESISTANCES ARE MEASURED TO GROUND WITH A 20,000 OHM-PER-VOLT METER. USE HIGHER METER RANGES TO PREVENT CIRCUIT LOADING
2. NC INDICATES NO CONNECTION
3. † INDICATES READING WITH R10 FULLY CLOCKWISE
4. †† INDICATES READING WITH R44 FULLY CLOCKWISE
5. # INDICATES FILAMENT READING BETWEEN FILAMENT PINS
6. ## INDICATES READING BETWEEN TUBE PIN AND TERMINAL 4 OF T3
7. #✱ INDICATES READING BETWEEN TUBE PIN AND TERMINAL 3 OF T3

TM 689-466

Figure 338. Receiver power supply, tube socket voltage and resistance diagram.


TB2
Y1 6.3V A-C
913K
Y2 6.3V A-C
913K
X1 6.3V A-C
†
X2 6.3V A-C
†
-625V
405K
-475V
414K
-300V
452K
0V
0
Z1 6.3V A-C
*
Z2 6.3V A-C
*
+42V
8,200
+150V
31.6K
+250V
341K
SPARE
SPARE
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
TB3
0V
0
+250V
341K
+150V
31.6K
+42V
8,200
-300V
452K
-475V
414K
-625V
405K
SPARE
SPARE
X2 6.3V A-C
†
X1 6.3V A-C
†
Y2 6.3V A-C
913K
Y1 6.3V A-C
913K
Z2 6.3V A-C
*
Z1 6.3V A-C
*
TB4
SPARE
SPARE
115V A-C
∞
SPARE
115V A-C
∞
115V A-C
∞
115V A-C
115V A-C
∞
115V A-C COM
∞
SPARE
115V A-C
∞
SPARE
115V A-C
∞
115V A-C
115V A-C COM
∞
TB1
SPARE
115V A-C
∞
115V A-C
∞
COM 115V A-C
∞
115V A-C
∞
115V A-C
∞
115V A-C
∞
115V A-C
∞
REAR OF CHASSIS
TM689-489

NOTES

1 UNLESS OTHERWISE SHOWN. VOLTAGES AND RESISTANCES ARE MEASURED TO GROUND WITH A 20,000 OHM-PER-VOLT METER USE HIGHER METER RANGES TO PREVENT CIRCUIT LOADING

2. * INDICATES READING OF LESS THAN 1 OHM

3 † INDICATES READING OF R145 COUNTERCLOCKWISE 414K CLOCKWISE 452K

Figure 339. Receiver power supply terminal strip, voltage and resistance diagram.

]

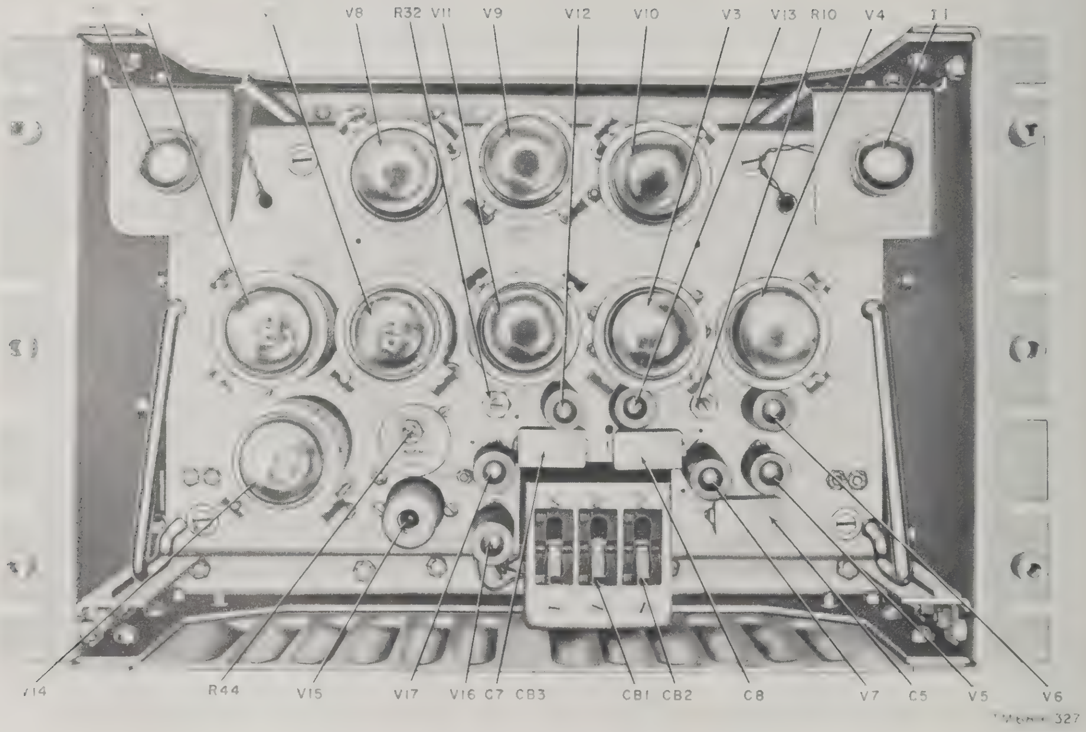

V8
R32
V11
V9
V12
V10
V3
V13
R10
V4
I1
V14
R44
V15
V17
V16
C7
CB3
CB1
CB2
C8
V7
C5
V5
V6
327

Figure 340. Receiver power supply, front view.

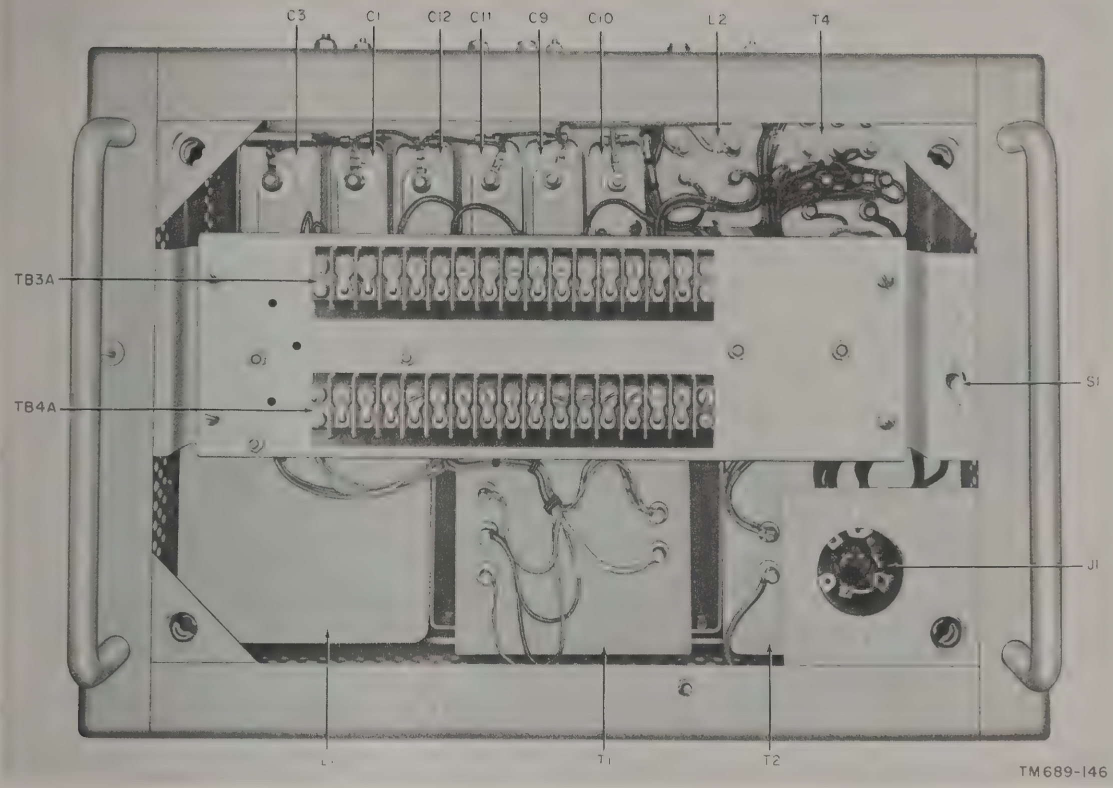

C3
C1
C12
C11
C9
C10
L2
T4
TB3A
TB4A
S1
J1
L1
T1
T2
TM689-146

Figure 341. Receiver power supply, rear view.

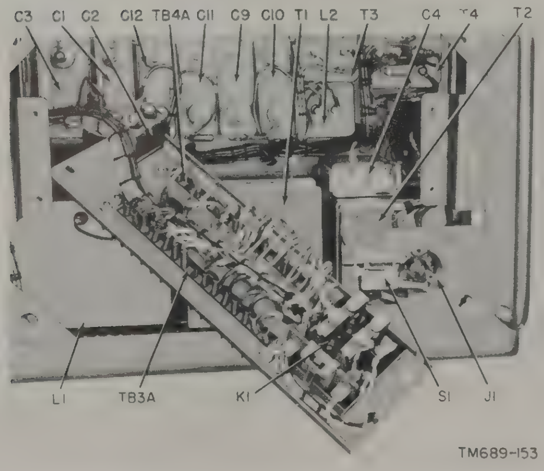

C3
C1
C2
C12
TB4A
C11
C9
C10
T1
L2
T3
C4
T4
T2
L1
TB3A
K1
S1
J1
TM689-153

Figure 342. Receiver power supply, rear view, terminal board swung down.

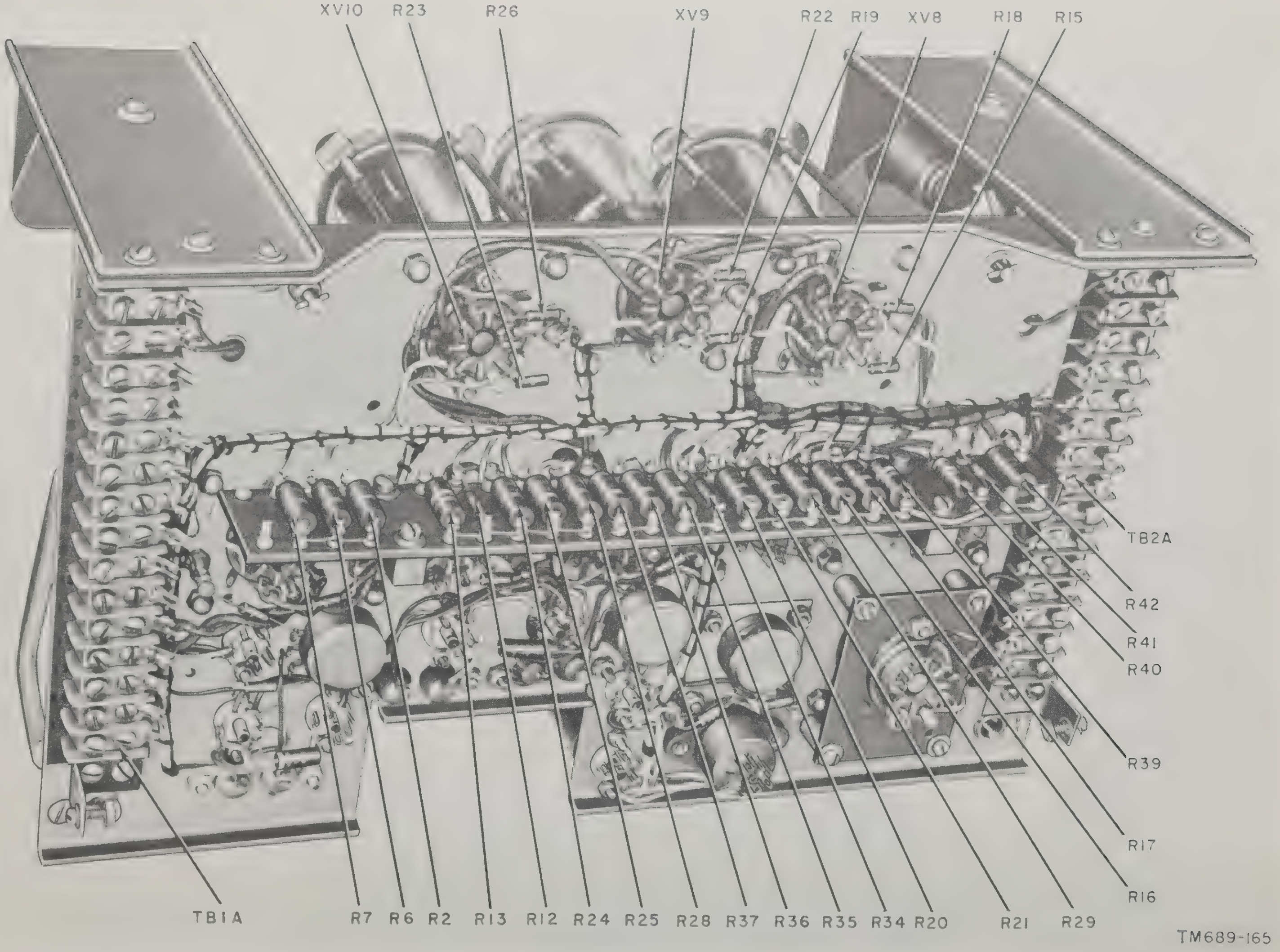

XV10
R23
R26
XV9
R22
R19
XV8
R18
R15
TB2A
R42
R41
R40
R39
R17
R16
TB1A
R7
R6
R2
R13
R12
R24
R25
R28
R37
R36
R35
R34
R20
R21
R29
TM689-165

Figure 343. Receiver power supply, upper rear view.

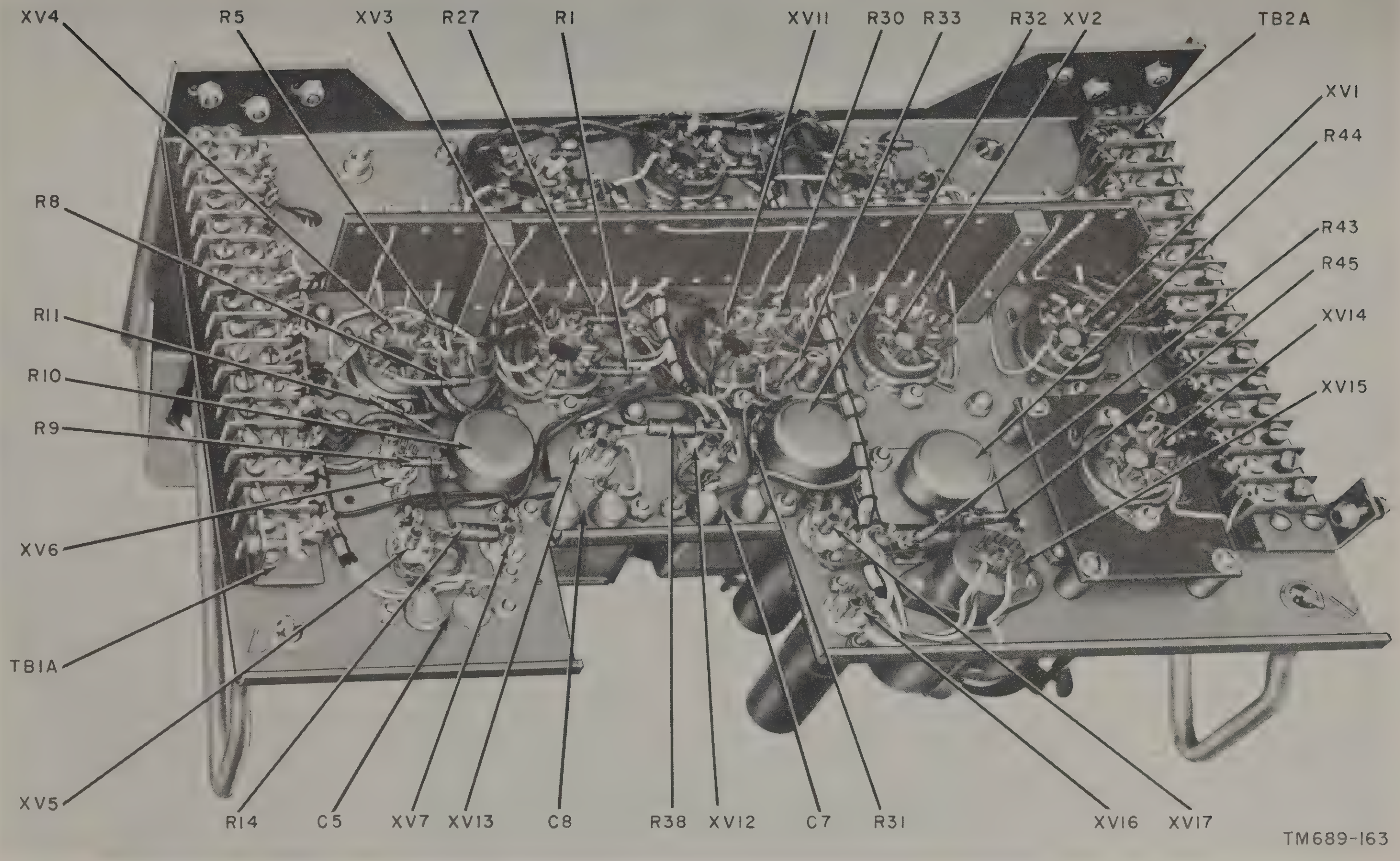
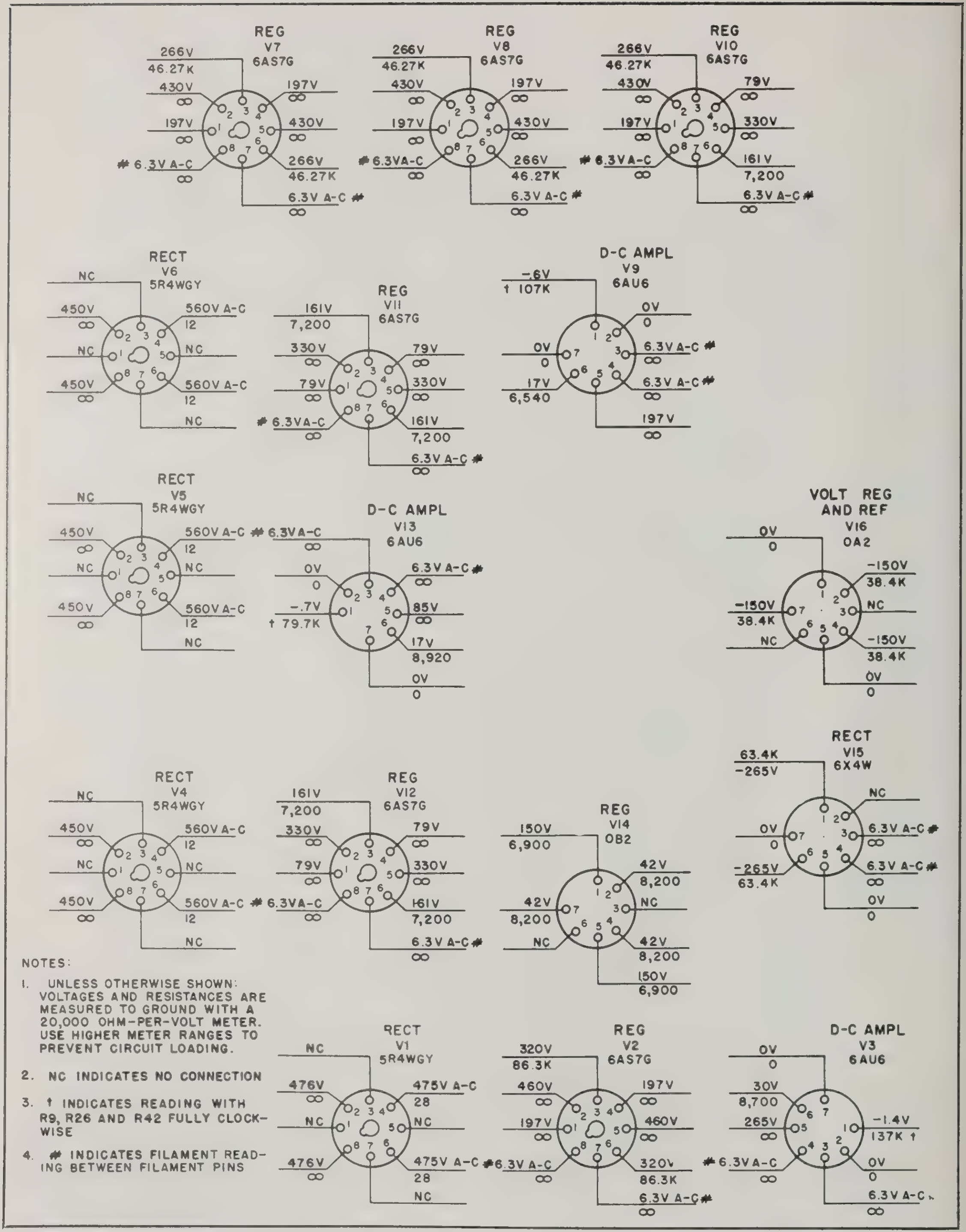

XV4
R5
XV3
R27
R1
XV11
R30
R33
R32
XV2
TB2A
XV1
R44
R43
R45
XV14
XV15
R8
R11
R10
R9
XV6
TB1A
XV5
R14
C5
XV7
XV13
C8
R38
XV12
C7
R31
XV16
XV17
TM689-163

Figure 344. Receiver power supply, lower rear view.

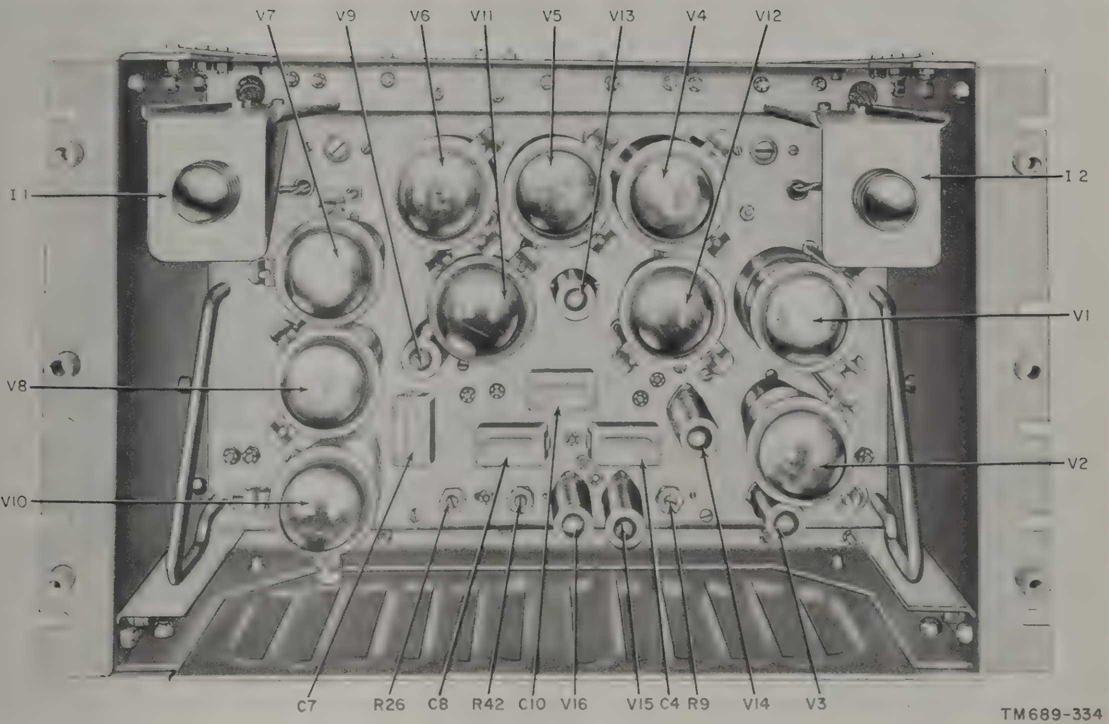

REG
V7
6AS7G
266V
46.27K
430V
∞
197V
∞
197V
∞
430V
∞
# 6.3V A-C
∞
266V
46.27K
6.3V A-C #
∞
REG
V8
6AS7G
266V
46.27K
430V
∞
197V
∞
197V
∞
430V
∞
# 6.3VA-C
∞
266V
46.27K
6.3V A-C #
∞
REG
V10
6AS7G
266V
46.27K
430V
∞
79V
∞
197V
∞
330V
∞
# 6.3VA-C
∞
161V
7,200
6.3V A-C #
∞
RECT
V6
5R4WGY
NC
450V
∞
560V A-C
12
NC
NC
450V
∞
560V A-C
12
NC
REG
V11
6AS7G
161V
7,200
330V
∞
79V
∞
79V
∞
330V
∞
# 6.3VA-C
∞
161V
7,200
6.3V A-C #
∞
D-C AMPL
V9
6AU6
-.6V
† 107K
0V
0
0V
0
6.3V A-C #
∞
17V
6,540
6.3V A-C #
∞
197V
∞
RECT
V5
5R4WGY
NC
450V
∞
560V A-C
12
NC
NC
450V
∞
560V A-C
12
NC
D-C AMPL
V13
6AU6
# 6.3VA-C
∞
0V
0
6.3V A-C #
∞
-.7V
† 79.7K
85V
∞
17V
8,920
0V
0
VOLT REG
AND REF
V16
0A2
0V
0
-150V
38.4K
-150V
38.4K
NC
NC
-150V
38.4K
0V
0
RECT
V15
6X4W
63.4K
-265V
NC
0V
0
6.3V A-C #
∞
-265V
63.4K
6.3V A-C #
∞
0V
0
RECT
V4
5R4WGY
NC
450V
∞
560V A-C
12
NC
NC
450V
∞
560V A-C
12
NC
REG
V12
6AS7G
161V
7,200
330V
∞
79V
∞
79V
∞
330V
∞
# 6.3VA-C
∞
161V
7,200
6.3V A-C #
∞
REG
V14
0B2
150V
6,900
42V
8,200
42V
8,200
NC
NC
42V
8,200
150V
6,900
RECT
V1
5R4WGY
NC
476V
∞
475V A-C
28
NC
NC
476V
∞
475V A-C
28
NC
REG
V2
6AS7G
320V
86.3K
460V
∞
197V
∞
197V
∞
460V
∞
#6.3V A-C
∞
320V
86.3K
6.3V A-C #
∞
D-C AMPL
V3
6AU6
0V
0
30V
8,700
265V
∞
-1.4V
137K †
# 6.3VA-C
∞
0V
0
6.3V A-C
∞

NOTES:

1. UNLESS OTHERWISE SHOWN: VOLTAGES AND RESISTANCES ARE MEASURED TO GROUND WITH A 20,000 OHM-PER-VOLT METER. USE HIGHER METER RANGES TO PREVENT CIRCUIT LOADING.
2. NC INDICATES NO CONNECTION
3. † INDICATES READING WITH R9, R26 AND R42 FULLY CLOCKWISE
4. # INDICATES FILAMENT READING BETWEEN FILAMENT PINS

TM 689-464

Figure 345. Low-voltage power supply, tube socket voltage and resistance diagram.



V7
V9
V6
V11
V5
V13
V4
V12
I1
I2
V1
V8
V2
V10
C7
R26
C8
R42
C10
V16
V15
C4
R9
V14
V3
TM689-334

Figure 346. Low-voltage power supply, front view.

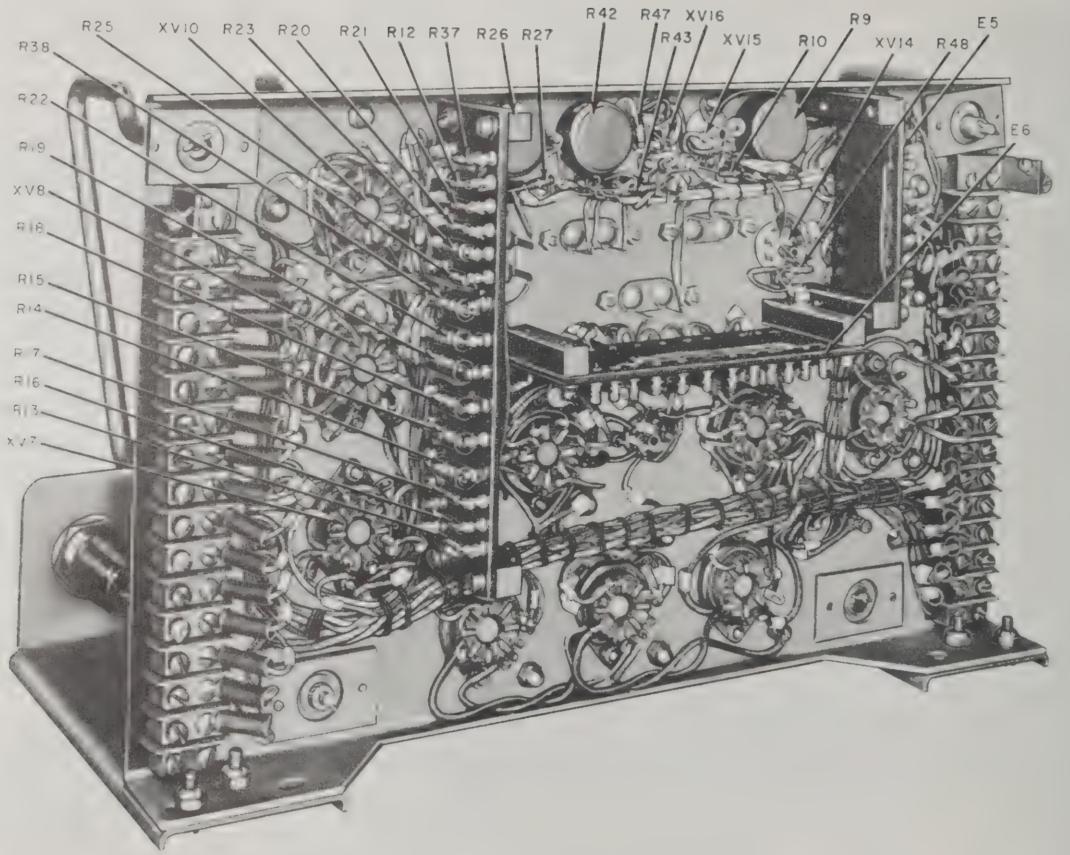

R25
XV10
R23
R20
R21
R12
R37
R26
R27
R42
R47
XV16
R43
XV15
R10
R9
XV14
R48
E5
E6
R38
R22
R19
XV8
R18
R15
R14
R17
R16
R13
XV7

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Figure 347. Low-voltage power supply, left hand rear view.

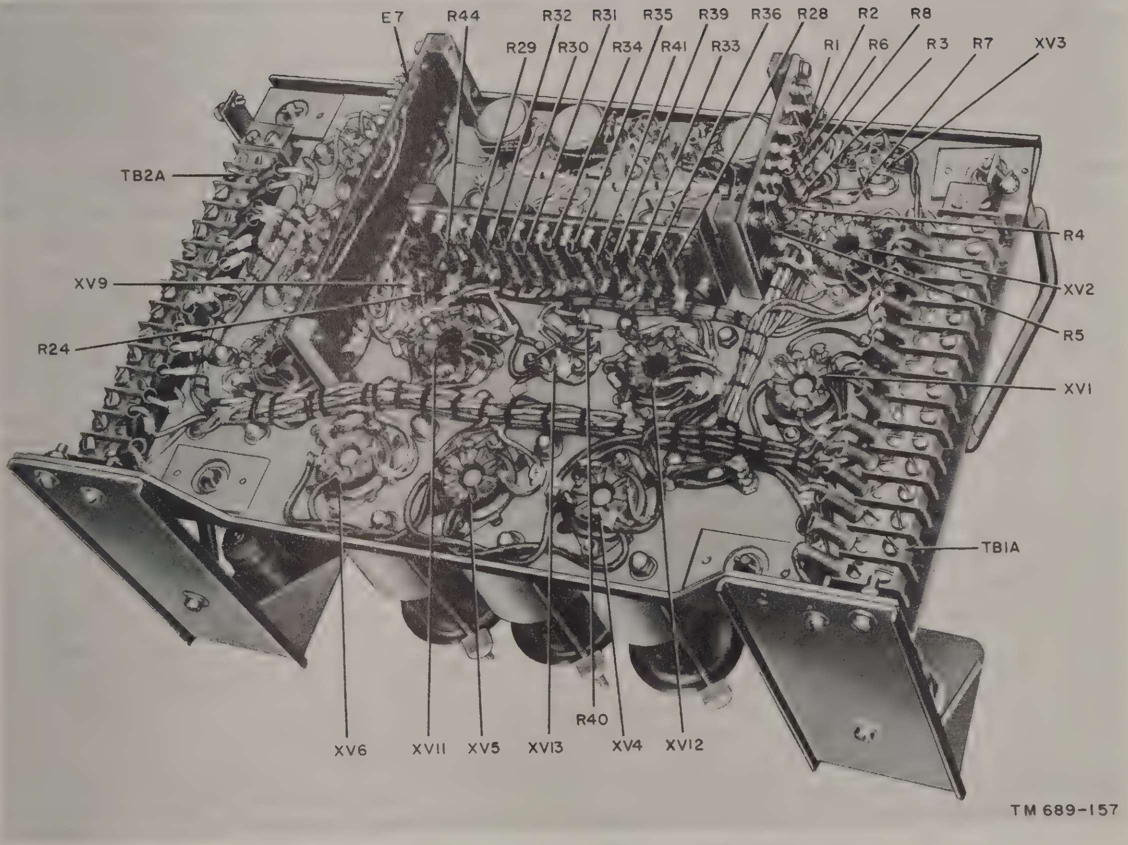
E7
R44
R32
R31
R35
R39
R36
R28
R2
R8
R29
R30
R34
R41
R33
R1
R6
R3
R7
XV3
TB2A
R4
XV2
XV9
R5
R24
XV1
TB1A
XV6
XV11
XV5
XV13
R40
XV4
XV12
TM 689-157

Figure 348. Low-voltage power supply, top rear view.

b. In the radio transmitter and high-voltage power supply, do *not* turn on the high-voltage power supply (KLYSTRON HV and PA PLATE switches on the high-voltage power supply should be in the OFF position) until circuits that use the high voltages are required. If high voltage is required, place the INPUT POWER BREAKER circuit breakers on the high-voltage supply to the OFF positions before connecting the meter probe to the circuit being tested; place the INPUT POWER BREAKER circuit breakers in the ON position. Allow for the 1-minute time delay, and note the meter reading. Finally, place the INPUT POWER BREAKER in the OFF position, and withdraw the probe.

c. Careless replacement of parts often makes new faults inevitable. Note the following points:

(1) Before a part is unsoldered, note the position of the leads. If a part, such as a transformer, has a number of connections, tag each of the leads to it.

(2) Be careful not to damage other leads by pulling or pushing them out of the way.

(3) Do not allow drops of solder to fall into the set, since they may cause short circuits.

(4) A carelessly soldered connection may create a new fault. It is very important to make well-soldered joints, since a poorly soldered joint is one of the most difficult faults to find.

(5) When a part is replaced in an if., rf, subcarrier, or discriminator circuit, it must be placed exactly as the original one was. A part that has the same electrical value but different physical size may cause trouble in these circuits. Give particular attention to proper grounding when replacing a part. Use the same ground as in the original wiring. Failure to observe these precautions may result in decreased gain or possibility of oscillation of the circuit. Also, when replacing protective shields for if. amplifier, modulator, and crystal multipliers, be sure that the shield is making good contact with the chassis and that all fasteners are tight. Power must be turned off when removing or replacing these protective shields.

223. Checking Filament and B+ Circuits for Shorts

a. Trouble within the radio set often may be detected by checking the resistance values of all terminal boards in the power supplies (figs. 307 and 338). This checks the filament and B+ circuits of the radio transmitter and radio receiver as well as the power supplies involved. The order-wire transmitter is checked by noting the resistance across C35 to ground. It should be greater than 100K (fig. 410). The order-wire receiver is checked by measuring the resistance between C26B to ground (fig. 399). It should be greater than 10K.

b. When a short is noted in one of the power supplies, or if one of the circuit breakers keeps throwing, indicating an overload condition in its associated circuit, the power supply output lead should be disconnected. Determine whether the short exists in the power supply or in its output circuit by measuring resistances to ground of the power supply terminal and of the disconnected lead. Check the wiring and components in the circuit indicating a short until the cause of the short is determined. After the fault is located and corrected, reconnect the power supply output lead to its terminal.

c. Reference should be made to the transmitter and receiver rack interconnection diagrams (figs. 391 and 401) and power distribution diagrams (figs. 266 and 267). These diagrams aid in tracing the filament and B+ circuits.

224. Operational Test

a. General.

(1) The equipment should be operated and checked as described in the checklists in paragraphs 131 and 132. The meter reading charts that are made up during preventive maintenance procedures also should be reviewed. These charts and the equipment performance checklists are important because they frequently indicate the general location of the trouble. Also listen for crackling or buzzing noises that indicate high-voltage arcing. Check the equipment for smoke and the odor of burned or overheated parts.

(2) In many cases, the trouble can be localized to a single stage by performing the procedures indicated in (1) above. In this case, assuming that all pluck-out items have been checked as described in chapter 4, the best procedure for localizing trouble within the stage is to check the tube voltage and resistance values against the values given on the voltage and resistance diagrams.

b. Use of Equipment Performance Checklist. The equipment performance checklist (par. 132) generally localizes trouble to a single, or several stages. In some items, reference is made to chapter 7 for corrective maintenance or alinement procedures. This reference was made because corrective maintenance or alinement for these items requires a higher degree of skill or test equipment not normally available to organizational personnel. Described below in *c* and *d* are the corrective maintenance and other measures required for these items *only* and *continue on from where the checklist in paragraph 132 left off*. That is, it is assumed that maintenance personnel have performed all actions indicated in paragraph 132 and have been referred to chapter 7 for further action. Note that these charts use the same columns described in paragraph 131*b* except that the item numbers used in *Item No.* column are the *same* used in the associated equipment performance checklist so that cross reference between the two charts can readily be made.

c. Transmitter Field Maintenance Equipment Performance Checklist. The transmitter field maintenance equipment performance checklist is below.

Item No.	Item, action or condition	Normal indications	Other condition	Corrective measures	Other measures
4	LINE VOLTS meter on radio transmitter.	Between 103.5 and 126.5	INPUT POWER BREAKERS in ON position.	If circuit breakers keep throwing, check for short, or partial short, between these circuit breakers and POWER circuit breakers in radio transmitter and in radio receiver.	
5	Place POWER switch in ON position.	POWER lamp in high-voltage power supply should go on. All filaments in radio transmitter, plus V11 filament in high-voltage power supply should go on.	----------------	If circuit breaker keeps throwing, check filament circuit of all tubes in radio transmitter and tube V11 in high-voltage power supply. In radio transmitter, this can be done best by disconnecting fanning strip from each subassembly terminal board and checking filament leads on that fanning strip for short. If short is localized to subassembly, check each tube circuit in that subassembly.	
10	Place LV PLATE switch in high-voltage power supply in ON position.	LV PLATE lamp in low-voltage power supply should go on.	----------------	If circuit breaker keeps throwing, check transformer T2 in low-voltage power supply for shorts. Check for short between pins M and P in J1 and cable.	
11	+150V meter reading on radio transmitter METER B.	95 to 105	----------------	Check operation of low-voltage power supply and adjust +150V ADJ control as described in paragraph 249.	Record meter reading obtained in meter chart.

Item No.	Item, action or condition	Normal indications	Other condition	Corrective measures	Other measures
12	+250V meter reading on radio transmitter METER B.	95 to 105		Same as item 11, adjusting +250V ADJ control.	Same as item 11.
13	+300V meter reading on radio transmitter METER B.	95 to 105		Same as item 11, adjusting +300V ADJ control.	Same as item 11.
14	Place KLYSTRON HV switch on high-voltage power supply in ON position.	HV PLATE ON lamp and blower motor should go on.		If circuit breaker keeps throwing, check transformer T2 and associated circuit in high-voltage power supply for short. If blower motor does not operate, check C151 and powerlines to blower motor (par. 229*d*).	
15	BEAM V meter reading on radio transmitter METER B.	97 to 103		Check high-voltage power supply and adjust BEAM V ADJUST control as described in paragraph 245.	Same as item 11.
16	Place PA PLATE switch on high-voltage power supply in ON position.	Circuit breaker stays ON.		If circuit breaker keeps throwing, check transformers T3 and T4, and associated circuits, in high-voltage power supply for short.	
17	Place PLATE switch on order-wire transmitter in ON position.	+140V meter reading on order-wire transmitter should be between 90 and 110.		Check operation of power supply and adjust +140V ADJ control as described in paragraph 232*b*.	Same as item 11.
21	WAVEMETER setting	Less than 2.0 mc different from setting obtained during installation.	AFC CORRECTION+ and − and 1ST LIM GRID meter reading are proper.	Check stages V19, V20, and V21 (limiters and discriminator).	Check alinement of limiters and discriminator by determining that results described in paragraph 233*e*(3)(*j*) and (*k*)and 233*e*(7)(*b*) are obtained. If necessary, realine these stages.
36	DISCR+ and DISCR− meter readings on order-wire transmitter.	Average should be 0 ±10		Check stage V4 discriminator in order-wire transmitter.	Check alinement, and if necessary realine discriminator as described in paragraph 232*c*.

d. Receiver Field Maintenance Equipment Performance Checklist. The equipment performance checklist for receiver field maintenance follows:

Item No.	Item, action or condition	Normal indications	Other condition	Corrective measures	Other measures
4	Place POWER switch on radio receiver in ON position.	POWER lamp on receiver power supply should go on and filaments in radio receiver should light.	----------	If circuit breaker keeps throwing, check filament circuit of all tubes except V21 and V28 in radio receiver. This can best be done by disconnecting, one at a time, the fanning strip from each subassembly terminal board and checking filament leads on that fanning strip for a short. If short is localized to subassembly, check each tube circuit in that subassembly.	
7	Place LV PL switch in receiver power supply in ON position.	PLATE lamp should go on.	----------	If circuit breaker keeps throwing, check transformer T1 and associated circuit in receiver power supply for short.	
8	+250V meter reading on radio receiver METER B.	Between 95 and 110, after 15-minute warmup period.	----------	Check operation of receiver power supply and adjust +250V ADJ control as described in paragraph 248.	Record meter reading obtained in meter chart.
9	+150V meter reading on radio receiver METER B.	95 to 110	----------	Same as item 8, adjusting +150V ADJ control.	Same as item 8.
10	Place PLATE switch on order-wire receiver in ON position.	+140V meter reading on order-wire receiver between 90 and 110.	----------	Check operation of power supply and adjust +140V ADJ control as described in paragraph 234*b*.	Same as item 8.
11	Place HV PL switch on receiver power supply in ON position.	A BEAM V meter reading within five divisions of reading obtained during installation.	----------	*a.* If circuit breaker keeps throwing, check transformer T3 and associated power supply in receiver power supply. *b.* If installation reading unknown or unobtainable, refer to paragraph 239.	
17	AFC CORRECTION + and − meter readings on radio receiver METER A.	Average of two readings should not exceed 5.	Local oscillator is off by more than 2.0 mc, AFC IF. LEVEL meter reading is correct, and average AFC CORRECTION meter reading below 55.	Check discriminator circuit CR4 and CR5.	Check alinement of if. amplifiers and discriminator by determining that results described in paragraph 238*b* are obtained. If necessary, realine these stages.

Item No.	Item, action or condition	Normal indications	Other condition	Corrective measures	Other measures
20	BEAM CUR. meter reading on radio receiver METER A.	Meter reading within ±5 divisions of reading obtained at installation.	----------------	If reading obtained at installation unknown or unobtainable refer to paragraph 239.	
24	IF. DISCR FREQ HIGH and IF. DISCR FREQ LOW meter readings on radio receiver METER B.	Average 0 ±10----------	Rf signal picked up by this receiver is at proper frequency.	Check discriminator circuit V15.	Check alinement of discriminator (par. 237*f*). If necessary realine this stage.
28	DISCR+, DISCR− meter readings in order-wire receiver.	Average 0 ±20----------	Incoming order-wire carrier signal is at proper frequency.	Check discriminator V5 in order-wire receiver.	Check discriminator alinement as described in paragraph 234*d*.

225. Troubleshooting Charts

a. General.

(1) Three general categories of troubles are encountered in this equipment. These troubles are equipment failure, indication of imminent failure as noted by meter readings, and performance deterioration.

(2) In most cases, the equipment performance checklist (par. 132), supplemented by field maintenance charts (par. 224*c* and *d*), will localize trouble to a single stage or series of stages (such as the modulator, if. amplifier). Where trouble is localized to a series of stages, reference should be made to the troubleshooting charts in *d* through *g* below (covering order-wire transmitter, radio transmitter, order-wire receiver, and radio receiver) which, when possible, indicate procedures for further localizing trouble.

(3) The cause of performance deterioration can best be localized by checking suspected components in accordance with the final test procedures given in paragraphs 241 through 250. If the component checked does not meet the performance indicated in this section, then reference can be made to the troubleshooting charts given in *d* through *g* below which indicate the possible causes of trouble and corrective measures that can be taken.

(4) When trouble is localized to a single stage or circuit, voltage and resistance measurements of this stage ordinarily should be sufficient to isolate the defective part.

Note. Troubleshooting charts do not localize trouble within power supply circuits. When trouble is localized to such a circuit, the best procedure for determining the cause of trouble is to check voltages and resistances of each tube.

b. Meter Circuits.

(1) In all of the troubleshooting procedures given previously it has been assumed that the meter circuits are operating properly. These circuits should be checked for possible cause of trouble if one of the two following conditions exist:

(*a*) All meter readings for a particular meter are of approximately the same amount. The meter may be at fault.

(*b*) Trouble cannot be found in stage associated with an improper meter reading. If the equipment and/or stage meets all of the performance tests given in paragraphs 241 through 250, then trouble exists in the metering circuit.

(2) Reference should be made to the meter

charts given in paragraphs 169 and 183 as an aid in localizing trouble in either the radio transmitter or radio receiver meter circuits.

c. Use of Troubleshooting Charts. The following troubleshooting charts contain the four columns described in (1) through (4) below.

(1) The *symptom* column indicates the symptom that should be observed to take the procedures indicated in the following columns.

(2) The *possible trouble* column indicates the possible causes of trouble for the symptom indicated.

(3) The *further checks* column indicates additional checks that can be taken to determine the cause of trouble.

(4) The *corrective measures* column indicates procedures to be taken to determine the defective component and correct trouble.

d. Order-Wire Transmitter Troubleshooting Chart. The order-wire troubleshooting chart is given below:

Symptom	Possible trouble	Further checks	Corrective measures*
Audio output of 0.3 volts rms cannot be obtained at pin 7 of V2 with 0.776-volt rms, 1,000-cycle signal applied to pins A and B of J1. ORDER WIRE TEST SWITCH in OPR position.	*a.* Stage V1		Check V1 components including input connections. Adjust audio levels as described in paragraph 232*e*.
	b. Transformer T1		Check T1.
CARR LIM GRID meter reading low.	*a.* Stage V2	With Frequency Meter AN/URM–79 determine that 6.000-mc signal is obtained.	If proper 6-mc signal is not obtained, check V2 components including connections from V6. Realine V2 as described in paragraph 232*d*.
	b. Stage V3	Check for at least a 4-volt reading on vtvm at junction of C10 and R13.	Check V3 components, particularly grid circuitry.
CARR LIM GRID reading proper, but carrier output level low as determined in paragraph 243.	*a.* Stage V3	Check for at least 10-volt reading at junction of R16 and C36.	Check V3 components.
	b. Stage V4	Proper indication obtained in *a* above.	Check V4 components including bias applied to pin 7.
Discriminator cannot be alined as described in paragraph 232*c* or DISCR readings average more than ±10. Stage V3 is assumed to be operative.	*a.* Stage V8	Voltage at junction of R41 and C27 does not vary as T3 is tuned.	Check V8 components. Realine discriminator as described in paragraph 232*c*.
	b. Stage V7	Voltage at junction of R38 and R39 does not vary as T2 primary is tuned.	Check V7 components. Realine discriminator as described in paragraph 232*c*.
	c. Stage V6	Variation of secondary of T2 does not affect oscillator frequency, and oscillator frequency is same with AFC switch ON or OFF.	Check V6 components.

* After voltage and resistance measurements.

e. Radio Transmitter Troubleshooting Chart. The radio transmitter troubleshooting chart is given below:

Symptom	Possible trouble	Further checks	Corrective measures*
$\frac{\text{MODE OUT}}{\text{MODE IN}}$ ratio low, or 44 volts (±10 percent) is not obtained at modulator output for 0.1 volt input (par. 233*c*).	*a.* First feedback amplifiers V1 and V2.	See that 1.2 volts rms is obtained at pin 4, V3.	If 1.2 volts rms is not obtained, check V1 and V2 components.
	b. Second feedback amplifiers V3 to V6.	1.2 volts rms is obtained in *a* above.	Check V3 to V6 components.

* After voltage and resistance measurements.

Symptom	Possible trouble	Further checks	Corrective measures*
More than 100 millivolts of noise obtained at modulator output with MOD SEL SW in GND position (par. 244*a*).	*a*. First feedback amplifiers V1 and V2.	See that noise at pin 4, V3, is less than 2.5 millivolts.	Check filter capacitors in stages V1 and V2. Refer to chapter 6 for identification of filter capacitors in these stages. Replace tubes V1 and V2.
	b. Second feedback amplifiers V3 to V6.	Less than 2.5 millivolts of noise is obtained in *a* above.	Check filter capacitors in stages V3 to V6 using procedure outlined in *a* above. Replace tubes V3 to V6.
Frequency response characteristic indicated in paragraph 233*d* is not obtained.	*a*. First feedback amplifiers V1 and V2.	Check frequency response at pin 4, V3.	If proper frequency response is not obtained, check frequency determining elements, such as coupling and bypass capacitors.
	b. Second feedback amplifiers V3 to V6.	Proper frequency response noted in *a* above.	Check frequency determining elements in stages V3 to V6; follow procedure outlined in *a* above. Readjust modulator as described in paragraph 233*d*.
Spurious response (sudden dips or peaks noted while making frequency response measurements).	*a*. First feedback amplifiers V1 and V2.	Check for spurious response at pin 4, V3.	If spurious response is noted, check bypass capacitors in V1 and V2.
	b. Second feedback amplifiers V3 to V6.	Spurious response is not obtained in *a* above.	Check bypass capacitors in V3 to V6.
1ST LIM GRID meter reading low or if. amplifier cannot be alined as described in paragraph 233*e*.	If. amplifiers V13 through V18.	Check unit visually as described in paragraph 226*a*(2). Check voltages and resistances as described in paragraph 226*a*(3). Try signal tracing as described in paragraph 226*b*. See that response given in figure 370 is obtained using test setup described in paragraph 233*e*.	Check components of stage found to be defective, and replace defective component. Check if. amplifier alinement and, if necessary, realine it as described in paragraph 233*e*.
AFC CORRECTION average readings less than ±5 with klystron off frequency and if. amplifier operative or alinement indication in paragraph 233*e*(3) cannot be obtained.	*a*. First limiter V19.	See that voltage of 3 to 4 volts is obtained at E5.	Check V19 components. Replace component found to be defective. Check alinement of limiter and realine it, if necessary, as described in paragraph 233*e*.
	b. Second limiter V20 or discriminator V21.	Proper indication obtained in *a* above.	Check V20 and V21 components. Replace component found to be defective. Check alinement of discriminator and realine it, if necessary, as described in paragraph 233*e*.
Klystron off frequency and AFC CORRECTION reading over 15.	*a*. Chopper amplifier V23 or V24A.	Connect equipment as shown in figure 349. Rectangular wave displayed on scope should vary in amplitude as potentiometer is varied, and in polarity as polarity switch is placed in one position and then the other.	Check V23 and V24A components, including chopper if no rectangular wave, or one of improper duration, is obtained.
	b. Chopper stage V24B or V25.	With potentiometer adjusted for meter reading of −20 millivolts, 6-volt ±½-volt reading should be obtained at pin 3, V26. With potentiometer	Check V24B and V25 components.

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* After voltage and resistance measurements.

Symptom	Possible trouble	Further checks	Corrective measures*
		adjusted for meter reading of +20 millivolts, 6-volt ±1½-volt reading should be obtained at pin 7, V26.	
	c. Relay control stage V26.	With potentiometer adjusted to ±.01-volt, relay K3 actuates and with polarity switch reversed for −.01-volt reading, relay K2 actuates.	Check V26 components.
Sawtooth waveform cannot be obtained or adjusted as described in paragraph 233*i*.	Sawtooth oscillator V27.	----------------------------	Check V27 components. Adjust sawtooth output as described in paragraph 233*i*.
$\frac{\text{MON OUT}}{\text{MOD OUT}}$ ratio low, or MON OUT frequency response improper (par. 244*b*).	Video preamplifier V22.	Check calibration of *percent modulation* meter as described in paragraph 233*h*.	Check V22 components. Adjust VIDEO LEVEL control as described in paragraph 233*h*.
MON REC OUTPUT of 0.33-volt rms cannot be obtained as described in paragraph 244*a*(13) or frequency response improper (par. 244*b*).	Amplifier V33-------	----------------------------	Check V33 components.
PEAK VTVM meter reading not adjustable to 50 with VTVM SEL SW in MOD OUT position and voltage of 35.4-volt rms obtained at modulator output as described in paragraph 244*a*.	*a.* Feedback amplifiers V28 through V30.	With 500-cycle 0.5-volt rms, signal applied to pin 1, S2 (in position 2), a 11.1-volt rms (±1 volt) signal should be obtained at pin 8, V30.	If an output of 11.1 volts is not obtained, check V28 to V30 components. Adjust vtvm as described in paragraph 233*c*.
	b. Stage V31 or V32.	If proper indication is obtained in *a* above, trouble is in either V31 or V32.	Check V31 and V32 components. Adjust vtvm as described in paragraph 233*c*.
Communications are normal, proper MON REC OUTPUT signal obtained, but TRANSMITTER OPERATING lamp off.	*a.* Relay K4--------	Check to see whether relay is actuated. If it is, trouble is in relay contacts. If it is not, manually operate relay. Lamp should go on, otherwise trouble is in relay.	If lamp does not light with relay actuated, check relay and its connections.
	b. Stages V34 and V35.	Adjust MON OW PLATE TUN control for maximum ORDER WIRE CARR LEVEL meter reading. Meter reading in excess of 80 should be obtained.	Check V34 and V35 components if reading over 80 is not obtained.
	c. Stage V36--------	----------------------------	Check V36 if ORDER WIRE CARR LEVEL meter reading of greater than 80 is obtained.
Power output indicated in paragraph 244*c* is not obtained, but proper KLYSTRON POWER OUT meter reading obtained.	*a.* Power amplifier V37.	Place Wattmeter ME–69/U at output of slug tuner. Power output about one-fifth of that indicated in paragraph 244*c* should be obtained.	Check stage V37 if proper power output obtained in previous column.
	b. Slug tuner or double coupler.	Place Wattmeter ME–69/U at output of double coupler. Same power output noted in *a* above should be obtained.	If proper power output is obtained at double coupler, trouble is in slug tuner and it should be replaced. If proper power output is not obtained, replace double coupler.

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* After voltage and resistance measurements.

f. Order-Wire Receiver Troubleshooting Chart. The order-wire receiver troubleshooting chart is given below:

Symptom	Possible trouble	Further checks	Corrective measures*
OW CARR LEVEL meter reading low or carrier amplifiers and limiters cannot be alined as described in paragraph 234*c*.	*a*. Input filter	Apply signal to order-wire receiver as described in paragraph 234*c*(1) through (5). Increase in oscilloscope display should be noted at pin 1, V1, as C5 is varied.	If variation in level is not obtained, check input filter. Aline carrier amplifiers and limiters as described in paragraph 234*c*.
	b. Subcarrier amplifier V1.	Reading of at least 80 millivolts rms should be obtained on oscilloscope at pin 1, V2, with equipment connected as described in *a* above.	If 80-millivolt reading is not obtained, check V1 components. Aline equipment as described in paragraph 234*c*.
	c. Subcarrier amplifier V2.	Reading of at least 200 millivolts rms should be obtained at pin 1, V3, with equipment connected as described in *a* above.	If 200-millivolt reading is not obtained, check V2 components. Aline equipment as described in paragraph 234*c*.
	d. First limiter V3	Reading of at least 9 volts dc should be obtained at pin 1, V4, with equipment connected as described in *a* above.	If −9-volt reading is not obtained, check V3 components. Aline equipment as described in paragraph 234*c*.
	e. Second limiter V4.	Voltage at junction of R22 and R23 varies as ORDER-WIRE CARR LEVEL control in order-wire transmitter is varied.	Check V4 components. Aline equipment as described in paragraph 234*d*.
	f. Stage V7	Proper indications obtained in *a* through *e* above.	Check V7 components.
Average DISCR meter readings greater than ±20 or discriminator cannot be alined as described in paragraph 234*d*.	Discriminator V5	Zero reading at junction of R22 and R24 by adjustment of T4.	Check V5 components and aline discriminator as described in paragraph 234*d*.
Proper AUDIO meter reading not obtained, or order-wire voice communications cannot be obtained, or voltages of 0.776 volt and 1.25 volts cannot be obtained at pins E and K of REPEATER INTERCONN jack as described in paragraph 246*b*.	Audio amplifier V6	With equipment connected as described in paragraph 246*b*, reading of 0.776-volt rms cannot be obtained.	Check V6 components. Adjust AUDIO LEVEL control as described in paragraph 234*e*.
Alarm circuit cannot be adjusted as described in paragraph 84*b* (6) through (8), or proper order-wire communications can be maintained, but alarm signal is continually indicated.	Differential amplifier V7 or relay control tube V8A.		Check V7 and V8A including noise filter at grid of V7B and second limiter output to grid of V7A. Refer to paragraph 184*b*(3) for simplified schematic and description of this circuit.
Diversity operation cannot be obtained as described in paragraph 93.	Differential amplifier V9B or relay K1, V8B or CR3.		Check V8B and V9 components. Refer to paragraphs 210 and 211 for simplified schematics and description of this circuit.

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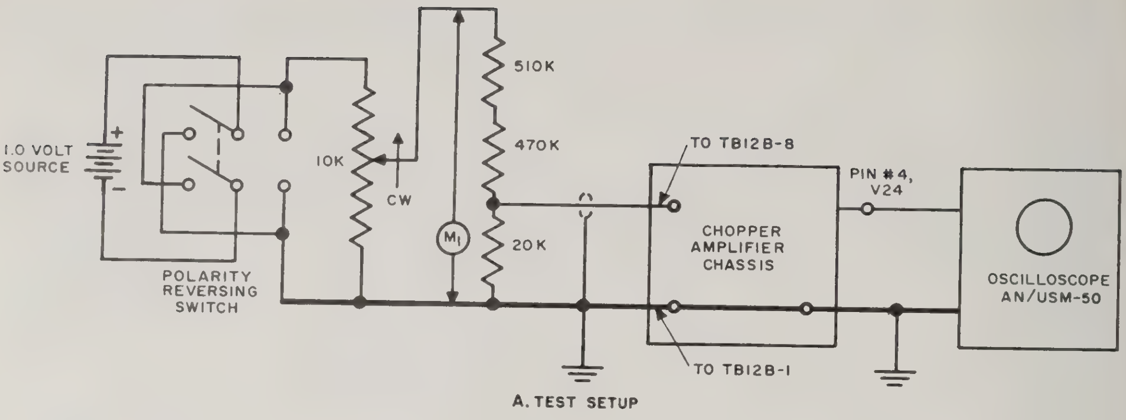
* After voltage and resistance measurements.

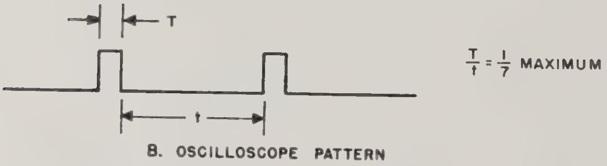
g. Radio Receiver Troubleshooting Chart. The radio receiver troubleshooting chart is given below:

Symptom	Possible trouble	Further checks	Corrective measures*
IF. LEVEL meter reading low, or proper receiver selectivity not obtained as described in paragraph 247*e*, or proper deviation sensivity is not obtained as described in paragraph 247*f*.	*a.* Preselector mixer.	Check preselector mixer as described in paragraph 131*d*.	Replace preselector mixer if defective. Aline it as described in paragraph 240.
	b. If. preamplifiers V1 through V6.	Check unit visually as described in paragraph 226*a*(2). Check voltages and resistances as described in paragraph 226*a*(3). Trace signal as described in paragraph 226*c*. See that response given in figure 375 is obtained using test setup described in paragraph 236.	Check components of stage found to be defective. Replace defective components. Check if. preamplifier alinement as described in *further checks* column and, if necessary, realine preamplifier.
	c. If. amplifiers V7 through V12, or agc amplifier V29.	Check unit visually as described in paragraph 226*a*(2). Check voltages and resistances as described in paragraph 226*a*(3). Trace signal as described in paragraph 226*d*. See that response given in figure 370 is obtained using test setup described in paragraph 237.	Check components of stage found to be defective and replace defective component. Check if. amplifier alinement as described in *further checks* column and, if necessary, realine if. amplifier.
	d. First limiter V13	See that voltage reading at E2 is between 3 and 4 volts when IF. LEVEL meter reading is 70.	Check V13 components if 3- to 4-volt reading is not obtained. Check alinement of limiter and realine if necessary, as described in paragraph 237*d*.
	e. Second limiter V14 or discriminator V15.	Proper results obtained in *a* through *d* above.	Check V14 and V15 components and replace defective component. Check alinement of discriminator and realine, if necessary, as described in paragraph 237*f*.
Afc does not pull in as described in paragraph 247*c*, or local oscillator is more than 2.0 mc off frequency.	*a.* Discriminator alinement.	Check discriminator response as described in paragraph 247.	If proper response curve is not obtained, aline as described in paragraph 238.
	b. Afc dc amplifier V28.		If proper response curve is obtained in *a* above, check V28 components. Retune local oscillator as described in paragraph 83.
Proper video response or signal is not obtained at VIDEO OUTPUT jack as described in paragraph 250, although it is known that radio transmitter, and preselector mixer, if. amplifier, and discriminator portions of the radio receiver, are operating properly.	*a.* Video amplifiers V17 through V20.	Connect test equipment to video amplifier as shown in figure 350. Figure 351 shows the equivalent generator network for the video amplifier. Measure linearity and response of amplifier. Curves shown in figures 352 and 353 should be obtained.	
	b. Composite video filter.	Repeat linearity response test indicated in *a* above with vtvm connected to VIDEO OUTPUT jack terminated in 50-ohm resistor.	Check composite video filter (in order-wire receiver) components.
	c. Video preamplifier V16.	Proper indications obtained in *a* and *b* above.	Check V16 components.

---

* After voltage and resistance measurements.


1.0 VOLT SOURCE
+
−
POLARITY REVERSING SWITCH
10K
CW
M1
510K
470K
20K
TO TB12B-8
TO TB12B-1
PIN #4, V24
CHOPPER AMPLIFIER CHASSIS
OSCILLOSCOPE AN/USM-50
A. TEST SETUP


T
t
$\frac{T}{t} = \frac{1}{7}$ MAXIMUM
B. OSCILLOSCOPE PATTERN

TM 689-471

Figure 349. Chopper test setup.

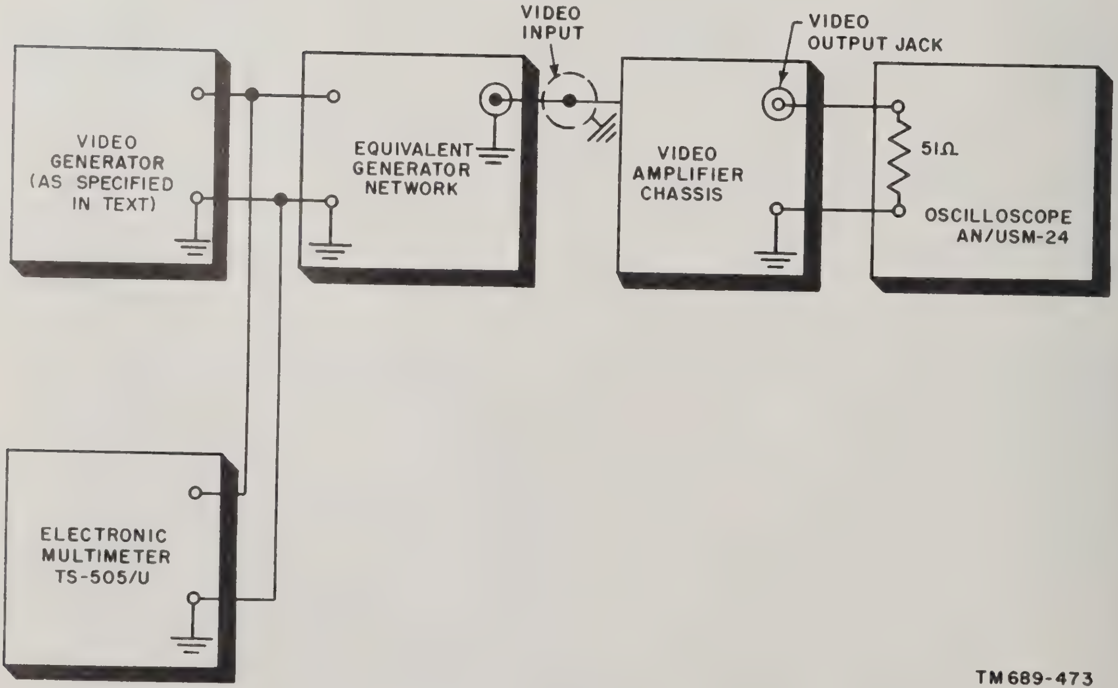
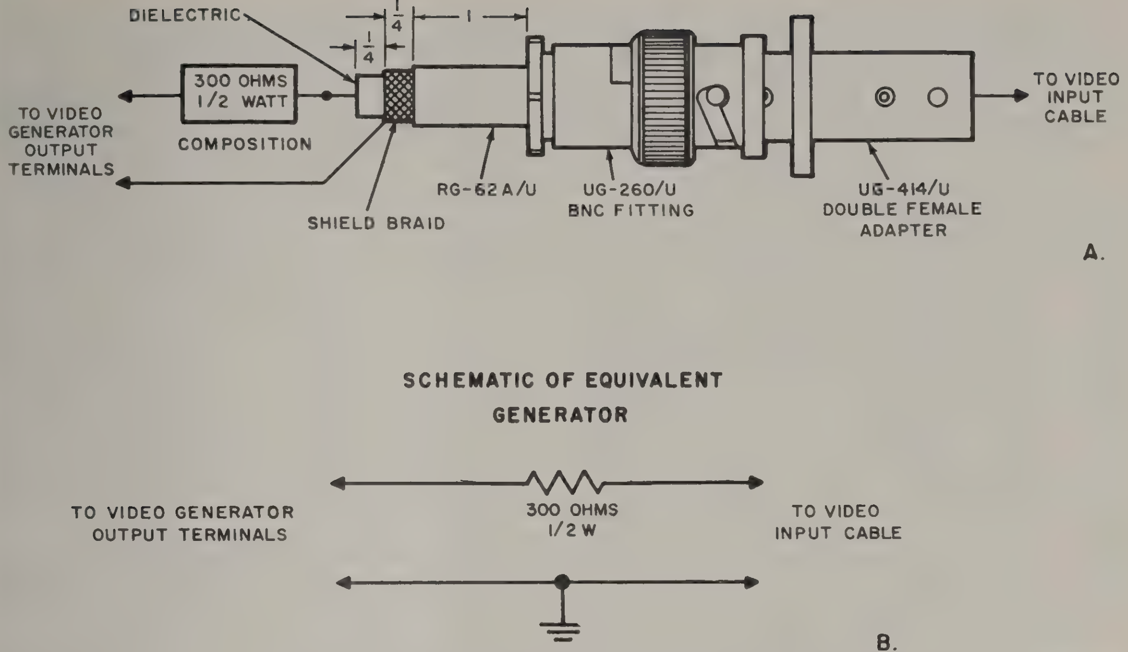
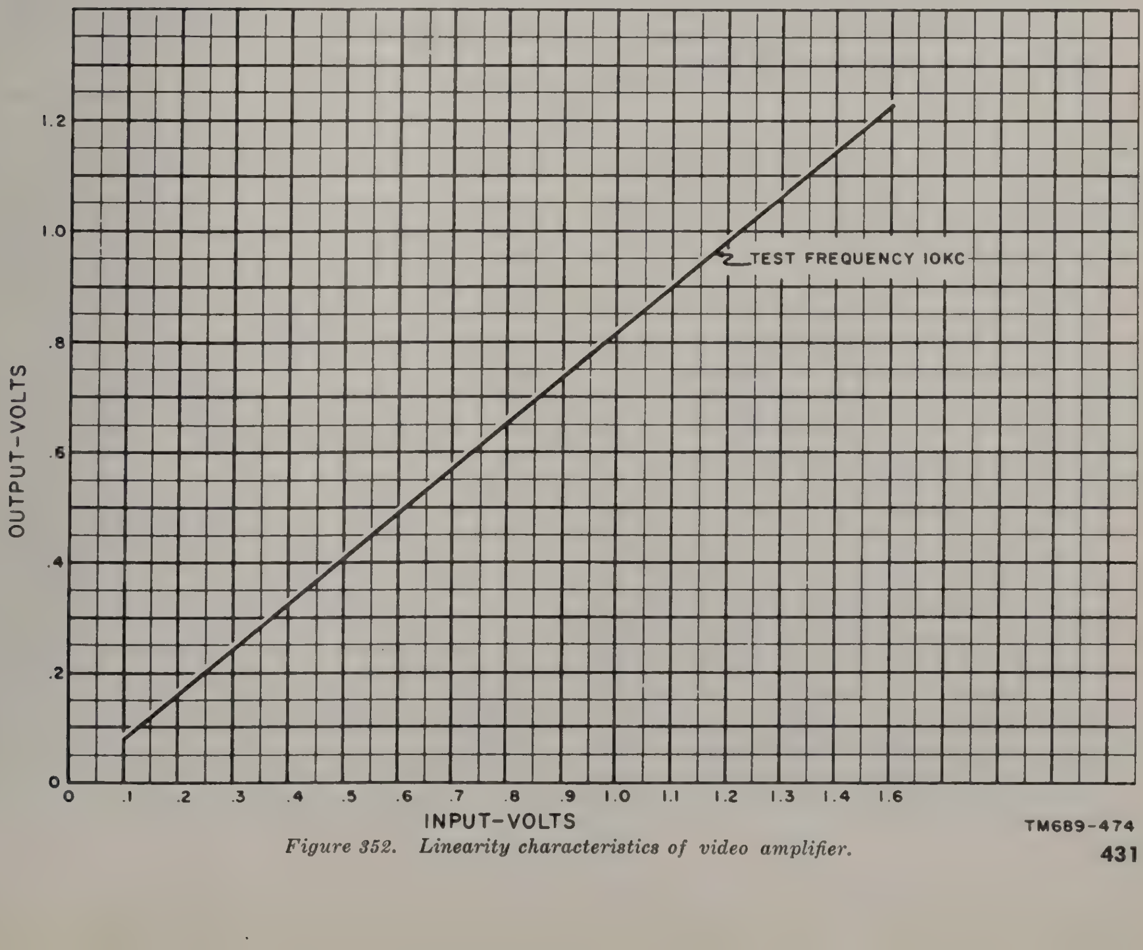

VIDEO GENERATOR (AS SPECIFIED IN TEXT)
EQUIVALENT GENERATOR NETWORK
VIDEO INPUT
VIDEO AMPLIFIER CHASSIS
VIDEO OUTPUT JACK
51Ω
OSCILLOSCOPE AN/USM-24
ELECTRONIC MULTIMETER TS-505/U
TM 689-473

Figure 350. Video amplifier test connections.


DIELECTRIC
1/4
1/4
1
300 OHMS
1/2 WATT
COMPOSITION
TO VIDEO GENERATOR OUTPUT TERMINALS
SHIELD BRAID
RG-62 A/U
UG-260/U BNC FITTING
UG-414/U DOUBLE FEMALE ADAPTER
TO VIDEO INPUT CABLE
A.
SCHEMATIC OF EQUIVALENT GENERATOR
TO VIDEO GENERATOR OUTPUT TERMINALS
300 OHMS
1/2 W
TO VIDEO INPUT CABLE
B.

TM689-472

Figure 351. Equivalent generator network for video amplifier.



TM689-474

Figure 352. Linearity characteristics of video amplifier.

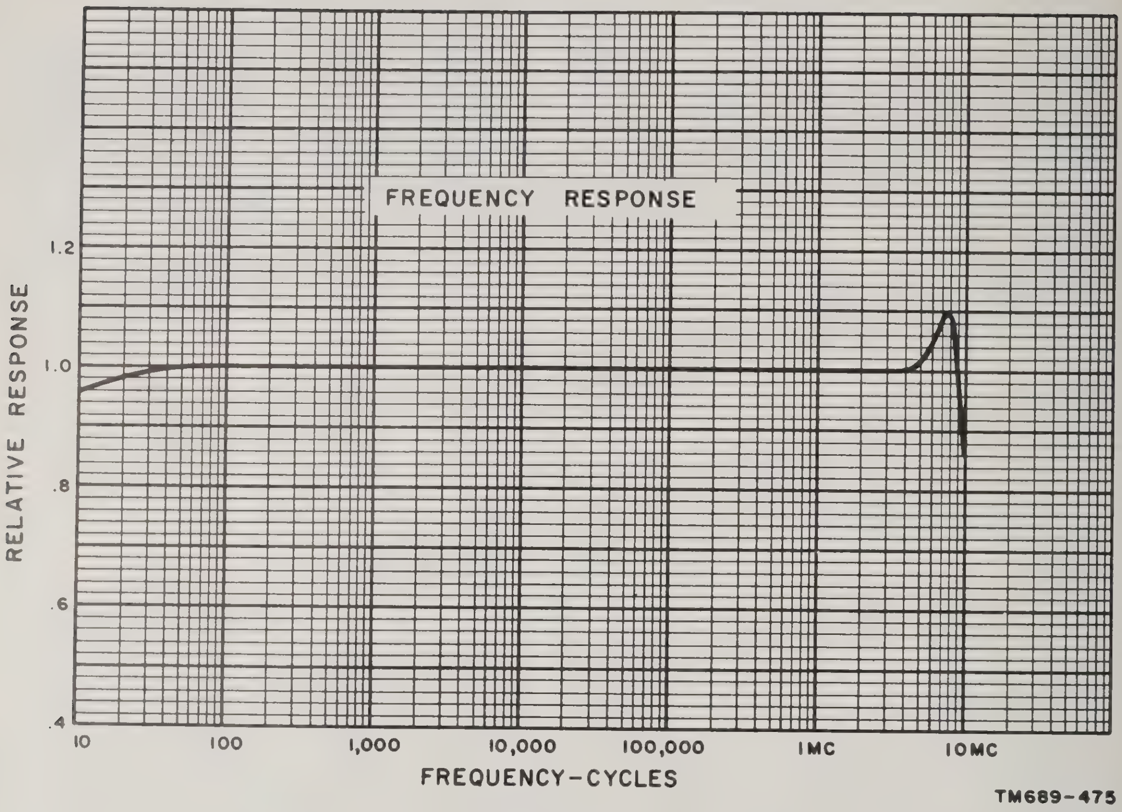


Figure 353. Frequency response of video amplifier.

226. Special 120-Mc If. Amplifier Troubleshooting Procedure

a. General.

(1) The general procedure given below can be used for troubleshooting the following 120-mc if. amplifiers: V13 through V18 in the radio transmitter; V1 through V6 (preamplifier) in the radio receiver; and V7 through V12 (if. amplifier) in the radio receiver.

(2) When trouble is localized to one of these if. amplifier subassemblies, first make sure that coaxial cable fittings to and from the assembly are securely in place and that the center conductor of the coaxial cable is making proper contact with the cable connector. Remove the shield covers and visually inspect assembly for burned-out resistors or other obvious cause of trouble.

(3) If visual inspection does not reveal the cause of trouble, check the pin socket voltages and resistances of each tube and examine components of any stage that provides abnormal voltage or resistance readings.

(4) If voltage and resistance measurements do not indicate a source of trouble, trace the signal through the amplifier as described in *b* through *d* below.

Note. The procedures indicated in *b* through *d* below are performed with if. shield covers removed. If spurious oscillations are obtained, the shield must be placed back on and connection to the tube pin must be made as illustrated in B, figure 354.

b. Radio Transmitter If. Amplifier Signal Tracing Procedure. The signal through the if. amplifier in the radio transmitter is traced as follows:

(1) Modify if. amplifier as described in paragraph 233*e*(1).

(2) Connect Signal Generator TS–497A/URR to if. amplifier input as shown in figure 369.

(3) Adjust the signal generator frequency to 120 mc and amplitude modulate it with a 400-cycle signal.

(4) Connect the oscilloscope to pin 6 of V13 through the test lead and resistor as illustrated in A, figure 354. Pull out tube V15.

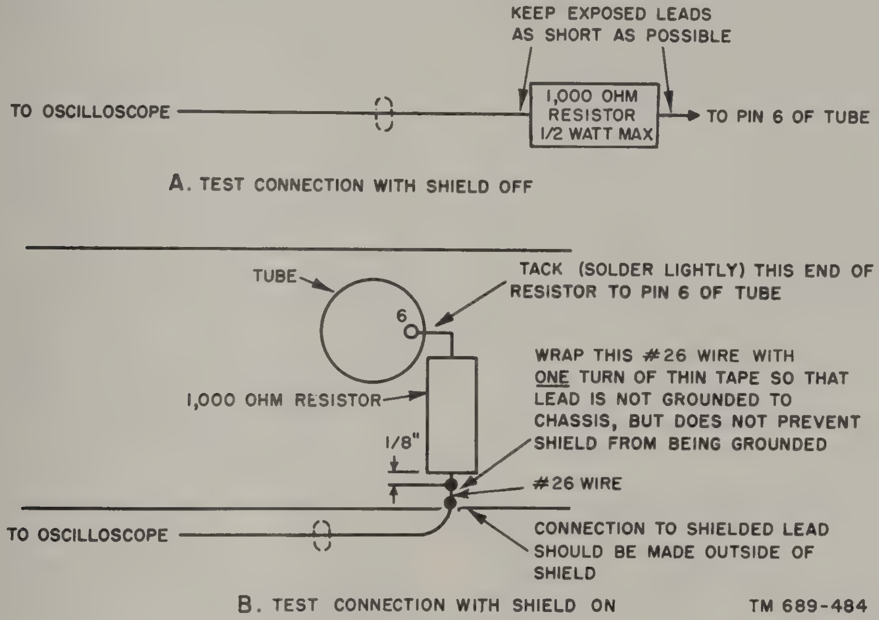

KEEP EXPOSED LEADS AS SHORT AS POSSIBLE
TO OSCILLOSCOPE
1,000 OHM RESISTOR 1/2 WATT MAX
TO PIN 6 OF TUBE
A. TEST CONNECTION WITH SHIELD OFF
TUBE
6
TACK (SOLDER LIGHTLY) THIS END OF RESISTOR TO PIN 6 OF TUBE
1,000 OHM RESISTOR
WRAP THIS #26 WIRE WITH ONE TURN OF THIN TAPE SO THAT LEAD IS NOT GROUNDED TO CHASSIS, BUT DOES NOT PREVENT SHIELD FROM BEING GROUNDED
1/8"
#26 WIRE
TO OSCILLOSCOPE
CONNECTION TO SHIELDED LEAD SHOULD BE MADE OUTSIDE OF SHIELD
B. TEST CONNECTION WITH SHIELD ON
TM 689-484

Figure 354. Test leads for if. amplifier signal tracing.

(5) Increase the signal generator output until a 400-cycle signal is observed on the oscilloscope. Adjust the signal generator output or scope controls until the peak-to-peak amplitude of the waveform covers about three-quarters the height of the face of the cathode-ray tube. If this 400-cycle signal cannot be obtained, trouble is in stage V13. Replace V15.

Note. In checking the output of each of the successive tubes as described in the following procedures, reduce the signal generator output level in approximately uniform steps to obtain the same signal amplitude on the oscilloscope.

(6) Connect the oscilloscope to pin 6, V14, and pull out V16. If the 400-cycle signal is not obtained, trouble is in stage V14. Replace V16.

(7) Connect the oscilloscope to pin 6, V15, and pull out V17. If the 400-cycle signal is not obtained, trouble is in V15. Replace V17.

(8) Connect the oscilloscope to pin 6, V16, and pull out V18. If the 400-cycle signal is not obtained, trouble is in stage V16. Replace V18.

(9) Connect the oscilloscope to pin 6, V17. Do not pull out tube V19. Refer to the note given in *a*(4) above if oscillation is observed. If the 400-cycle signal is not obtained, trouble is in stage V17. If this signal is obtained, trouble is in stage V18.

(10) Remove modification made in (1) above.

c. Radio Receiver If. Preamplifier Signal Tracing Procedure. The signal through the if. preamplifier of the radio receiver is traced as follows:

(1) Connect the signal generator, via its isolating pad, to the if. preamplifier input through the equivalent mixer as shown in figure 355.

(2) Adjust the signal generator frequency to 120 mc and amplitude modulate it with a 400-cycle signal.

(3) Connect the oscilloscope to pin 6 of V3 through the test lead and resistor as illustrated in A, figure 354. Pull out tube V5.

(4) Increase the signal generator output until a 400-cycle signal is observed on the oscilloscope. Adjust the signal generator output or scope controls until the peak-to-peak amplitude covers about three-quarters the height of the face of the cathode-ray tube. If this signal cannot be obtained, trouble is in stage V1, V2, or V3. Replace V5.

Note. In checking the output of each of the successive tubes as described in the following procedures, reduce the signal generator output level in approximately uniform steps to obtain the same signal amplitude on the oscilloscope.

(5) Connect the oscilloscope to pin 6, V4, and pull out tube V6. If a 400-cycle signal is not obtained, trouble is in stage V4. Replace V6.

(6) Connect the oscilloscope to pin 6, V5. Refer to the note given in *a*(4) above if oscillation is observed. If a 400-cycle signal is not obtained, trouble is in stage V5. If this signal is obtained, trouble is in stage V6.

d. Radio Receiver If. Amplifier Signal Tracing Procedure. The signal through the if. amplifier in the radio receiver is traced, and the agc dc amplifier is checked, as follows:

(1) Connect Signal Generator TS–497A/URR to the if. amplifier input as shown in figure 374. Ground the agc lead at terminal 8, TB4.

(2) Check stages V7 to V12 following the procedure outlined in *b*(3) through (9) above; substitute V7 for V13, V8 for V14, V9 for V15, V10 for V16, V11 for V17, and V12 for V18. Remove ground from the agc lead.

(3) Perform the procedures given in paragraph 240*a* through *e*.

(4) Increase the signal generator output to 2,000 microvolts.

(5) An IF. LEVEL meter reading in excess of 125 should be obtained.

(6) Turn the IF. LEVEL potentiometer counterclockwise and note the IF. LEVEL meter reading. It should decrease as the potentiometer is turned to a minimun of about 60. If this result is not obtained, trouble is probably in stage V29.

227. 34.5-Mc Discriminator Response Check

The 34.5-mc discriminator response curve is checked as follows:

a. Connect the equipment of the afc subassembly as shown in figure 379.

Note. In each of the following procedures, the signal generator output frequency should be checked on the frequency meter.

b. Set the signal generator frequency to 34.5 mc and vary its output level for a —0.5 reading on the multimeter. Note the output level of the signal generator.

c. Ground terminal 7 of the fanning strip to the chassis.

d. Connect the multimeter to terminal 6 of the fanning strip.

e. Keep the signal generator output level at the same value noted in *b* above and vary its frequency from 30 to 34.5 mc in 0.5-mc steps. Note and record the reading on the multimeter at each step.

f. Reverse the multimeter polarity switch so that it can indicate negative voltages.

g. Repeat the procedure given in *e* above, varying the signal frequency from 34.5 to 39 mc in steps of 0.5 mc.

h. Plot results obtained in *e* and *g* above.

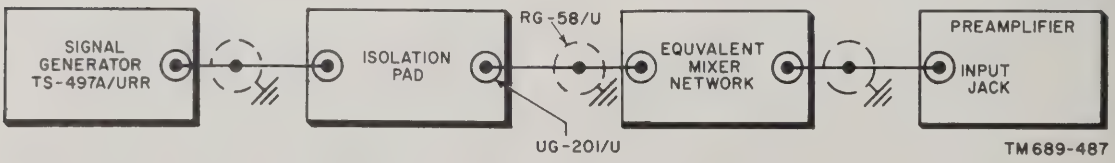


Figure 355. Test setup for if. preamplifier signal tracing.

They should be in agreement with the plot given in figure 227.

i. Remove ground from terminal 7.

228. Dc Resistances of Coils and Transformers

a. Order-Wire Receiver R–543/TRC–29.

Transformer, coil, or relay	Terminals	Dc resistance (ohms)
K1	6–13	9200.
K2	3–8	9200.
K3	6–7	500.
L1		Less than 1.
L3		Less than 1 (0.149 mh at 6.0 mc).
L4		Less than 1 (13.2 mh at 6.0 mc).
L5		85.
T1, T2, T3	BLUE–RED	1.2.
	GREEN–WHITE	1.2.
T4	BLUE–RED	
	GREEN	Less than 1.
	YELLOW–WHITE	
T5	1–2	310.
	3–7	11.
T6	1–2	42.
	3–4	2.3.
	5–6	Less than 1
T7	1–2	7.3.
	3–4–5	200 (100–100).

b. Radio Receiver R–418/G.

Transformer, coil, or relay	Terminals	Dc resistance (ohms)
L1		Less than 1.
L2		Less than 1.
L3		Less than 1.
L4		Less than 1.
L5		Less than 1.
L6		Less than 1.
L7		Less than 1.
L9		Less than 1.
L10		Less than 1.
L13		Less than 1.
L17		Less than 1.
L19		Less than 1.
L36		Less than 1.
L38		Less than 1.
L42		3.8.
L44		Less than 1.
L45		Less than 1.
L47		1.
L49	1–2	Less than 1.
L49	3–4	Less than 1.
L50		Less than 1.
L52		Less than 1.
L54		Less than 1.
L56		Less than 1.
L57		Less than 1.

c. Power Supply PP–690/G.

Transformer, coil, or relay	Terminals	Dc resistance (ohms)
K1	1–6	1,250.
L1		55.
L2		460.
T1	1–2	Less than 1.
	3–4–5	32 (16–16).
T2	1–2	Less than 1.
	3–4–5	Less than 1.
	6–7–8	Less than 1.
	9–10–11	Less than 1.
	12–13	Less than 1.
T3	1–2	10.
	3–4	150.
T4	1–2	10.
	3–4	Less than 1.
	5–6	34.
	7–8–9	Less than 1.

d. Power Supply PP–689/G.

Transformer, coil, or relay	Terminals	Dc resistance (ohms)
L1		130.
L2		43.
T1	1–2	1.
	3–4–5	Less than 1.
	6–7–8	Less than 1.
	9–10	Less than 1.
	11–12	Less than 1.
T2	1–2	Less than 1.
	3–4–5	54 (27–27).
	6–7–8	24.6 (12.3–12.3).
T3	1–2	54.
	3–4–5	1,490 (745–745).

e. Fixed Autotransformer Power Transformer TF–146/G.

Transformer, coil, or relay	Terminals	Dc resistance (ohms)
T1		0.07.

f. Radio Transmitter T–303/G.

Transformer, coil, or relay	Terminals	Dc resistance (ohms)
K1	1–6	100.
K2, K3, K4		11.3 K.
L1		0.30.
L3		0.50.
L4		Less than 1.
L5		Less than 1.
L6		Less than 1.
L7		Less than 1.
L8		Less than 1.
L9		Less than 1.
L11		Less than 1.
L21		Less than 1.
L23		Less than 1.
L25		Less than 1.
L27		Less than 1.
L29		3.8.
L30		Less than 1.
L31		0.90.

g. Power Supply PP–764/G.

Transformer, coil, or relay	Terminals	Dc resistance (ohms)
K1		60.
K2	2–3	2,200.
L1		115.
L2		810.
L3		130.
T1	1–2	2.8.
	3–4	Less than 1.
	5–6	Less than 1.
	7–8	Less than 1.
	9–10–11	Less than 1.
	12–13	Less than 1.
T2	1–2	Less than 1.
	3–4	230.
	5–6–7	93 (46.5–46.5).
T3		
	4–5	2.2.
	5–1	11.
	1–2	2.2.

g. Power Supply PP–764/G (cont).

Transformer, coil, or relay	Terminals	Dc resistance (ohms)
T4	1–2	1.
	3–4–5	366 (183–183).
T5	1–2	0.9.
	3–4–5	Less than 1.
	6–7	Less than 1.
	8–9	Less than 1.
	10–11–12	Less than 1.
	13–14–15	Less than 1.
	16–17–18	Less than 1.

h. Order-Wire Transmitter T–389/TRC–29.

Transformer, coil, or relay	Terminals	Dc resistance (ohms)
L1		Less than 1.
L2		Less than 1.
T1	1–2	250.
T1	3–7	11.
T2	BLUE–RED	0.8.
	GREEN–YELLOW–WHITE	Less than 1.
T3	BLUE–RED	1.2.
	GREEN–WHITE	1.2.
T4	1–2	7.3.
	3–4–5	200 (100–100).
T5	1–2	4.2.
	3–4	2.4.
	5–6	Less than 1.

i. Handset Signaling Unit H–102/TRC–29.

Transformer, coil, or relay	Terminals	Dc resistance (ohms)
I 1		20.

Section II. REPAIRS

229. Replacement of Parts

a. General.

(1) Be sure that the power is turned off before replacing any parts. Tag all leads removed from a part so that they may be replaced correctly. Refer to the appropriate wiring diagram when rewiring a replaced part. All hardware removed when replacing a defective part should be used for mounting the new item.

(2) Many of the parts mounted in the transmitter and receiver racks are readily accessible after removal of the individual unit rear covers. Figures 356 and 357 show the locations of the

rear cover fasteners. These figures also show the locations of the thumbscrews that secure the rear covers of the crystal multiplier and if. amplifier subchassis in the radio transmitter and if. amplifier, if. preamplifier, and afc amplifier subchassis in the radio receiver. Removal of these covers permits access to the parts mounted on the rear of the subchassis. Figures 358 and 359 show the locations of the thumbscrews that secure the front covers of the subchassis. Removal of these covers permits access to the parts mounted on the top of the subchassis.

(3) When necessary, individual units can be removed from the transmitter and receiver racks. Each rack consists of an outer framework to which is shock-mounted a welded inner frame (fig. 6). The units are mounted on the inner frame by means of screws. The inner frame is drilled and tapped for standard 19-inch relay rack spacing. Removable alining pins mounted on the frame guide the units into place. Units can be removed from the racks by first removing the appropriate fanning strip connections from the terminal blocks on the rear of the racks, and all unit interconnecting cables involved. Note that the plastic protective covers over the terminal blocks are provided with slots to facilitate removal of the fanning strip connections. After the disconnection of all interconnecting leads, the units can be taken out of the racks by removing the screws that mount them to the inner frame of the rack. When required, the frames on the front of the units that mount the access doors and handles can be removed by loosening the thumbbolts that secure them (figs. 358 and 359).

(4) Protective covers are mounted by screws to the sides and, in some cases, to the top and/or bottom of the units mounted in the racks. When removed, additional working space is provided for replacement of parts. The side covers can be removed with the units in place in the rack. To remove the top or bottom covers, the unit above or below the one being worked on would have to be removed from the rack.

b. Replacement of Klystrons. The klystrons used in the radio transmitter and radio receiver are replaced by following the procedures given in paragraph 133.

c. Replacement of Parts of Order-Wire Transmitter. For replacement of many of the parts of the order-wire transmitter, remove the unit from the rack and take off the top and side covers. Terminal board TB1A mounted on the rear of the unit also can be swung out by loosening the Dzus fasteners to facilitate replacement of parts.

d. Replacement of Blower Motor. The blower motor that cools the klystron and power amplifier triode in the radio transmitter is mounted to the rear wall of the main panel above the klystron (fig. 360). To remove the blower motor, proceed as follows:

(1) Remove the order-wire transmitter from the rack.
(2) Remove the radio transmitter top cover.
(3) Remove the radio transmitter side cover that mounts the air filter.
(4) Remove the radio transmitter rear cover and disconnect the leads to the blower motor.
(5) Remove the retaining ring that secures the cloth duct to the assembly. Be sure the duct does not adhere to the assembly.
(6) Remove the four bolts that mount the entire assembly to the transmitter. Hold the blower motor in place while removing the screws.
(7) Lower the blower motor assembly to clear the edge of the transmitter chassis and pull straight out. Be sure that the cloth duct is kept clear and not damaged.
(8) Install a new motor by reversing the procedure outlined above.

Note. To replace blower motor capacitor C151, it is necessary to remove the blower motor from the transmitter chassis.

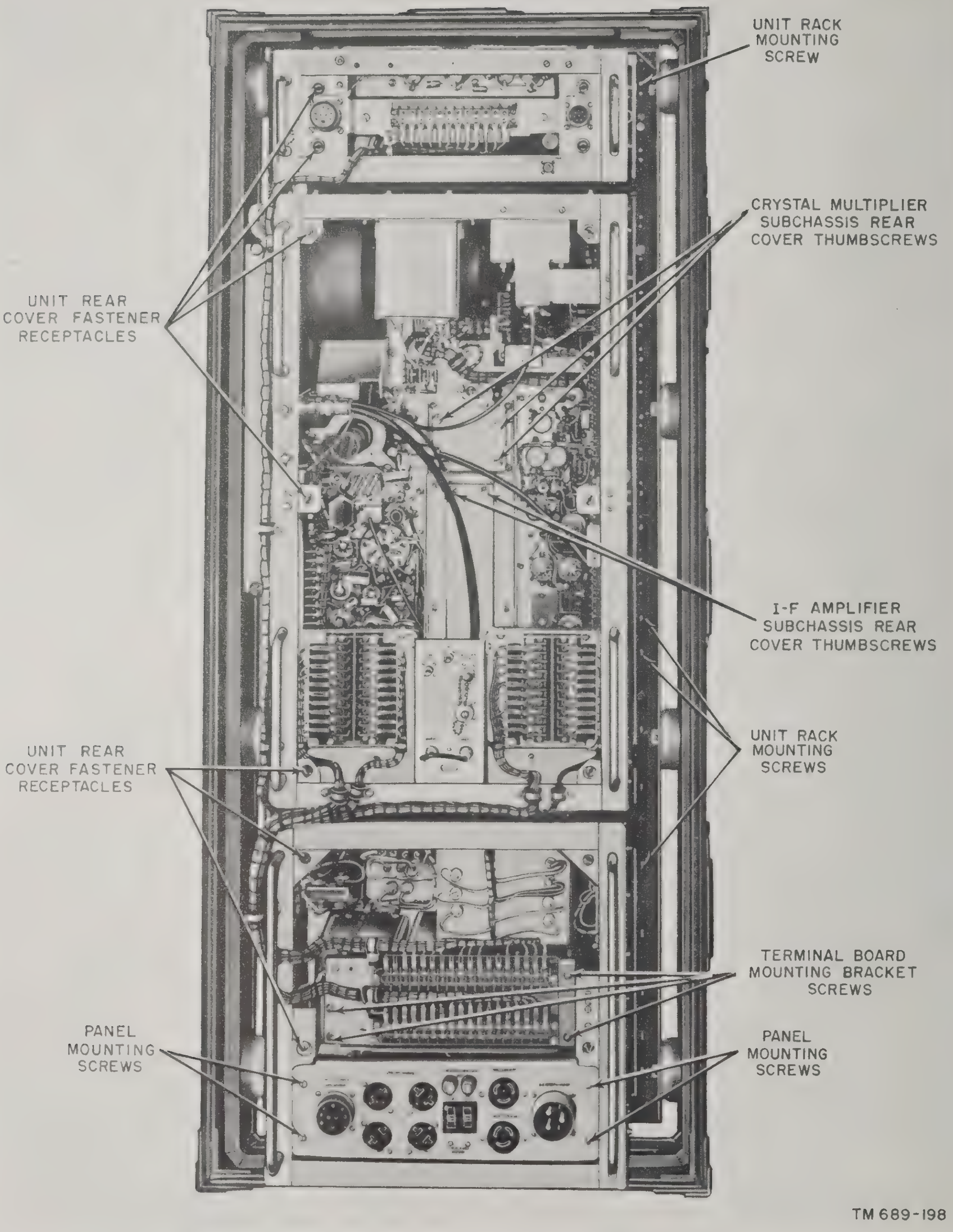

UNIT RACK MOUNTING SCREW
CRYSTAL MULTIPLIER SUBCHASSIS REAR COVER THUMBSCREWS
UNIT REAR COVER FASTENER RECEPTACLES
I-F AMPLIFIER SUBCHASSIS REAR COVER THUMBSCREWS
UNIT RACK MOUNTING SCREWS
UNIT REAR COVER FASTENER RECEPTACLES
TERMINAL BOARD MOUNTING BRACKET SCREWS
PANEL MOUNTING SCREWS
PANEL MOUNTING SCREWS
TM 689-198

Figure 356. Transmitter rack, rear view showing location of mounting facilities.

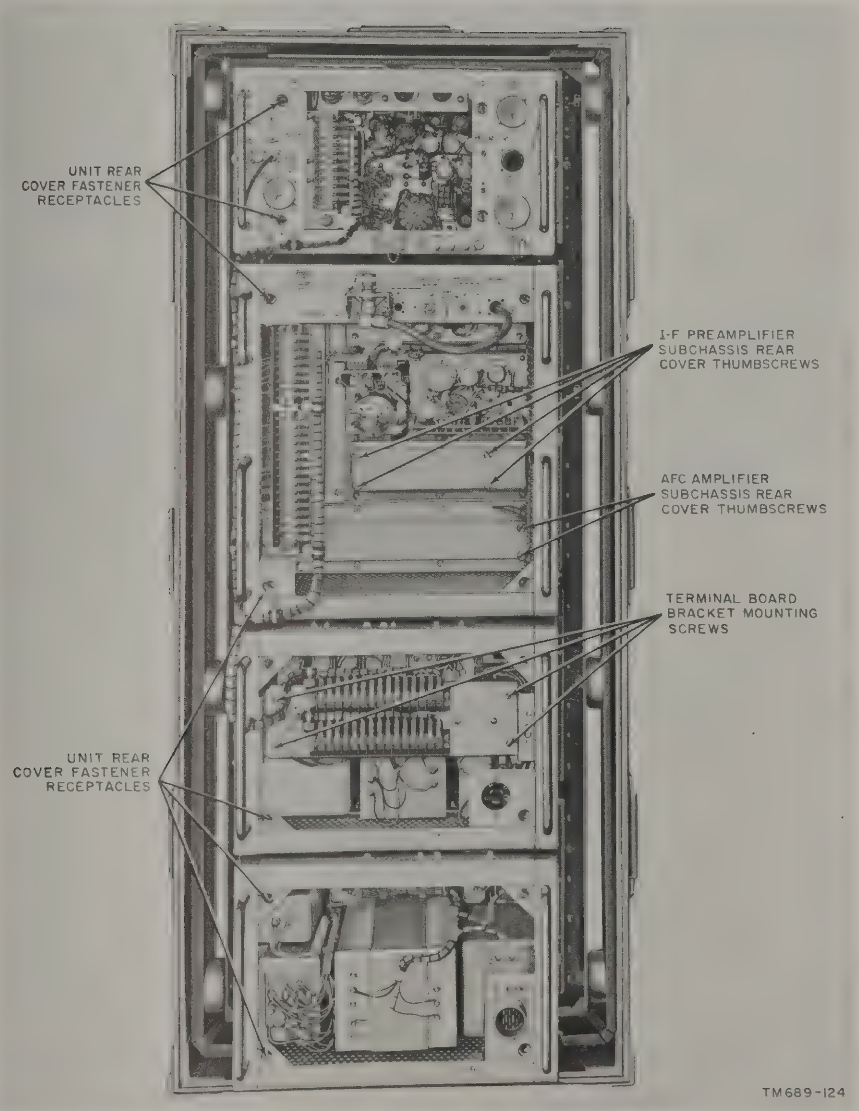

UNIT REAR COVER FASTENER RECEPTACLES
I-F PREAMPLIFIER SUBCHASSIS REAR COVER THUMBSCREWS
AFC AMPLIFIER SUBCHASSIS REAR COVER THUMBSCREWS
TERMINAL BOARD BRACKET MOUNTING SCREWS
UNIT REAR COVER FASTENER RECEPTACLES
TM689-124

Figure 357. Receiver rack, rear view showing location of mounting facilities.

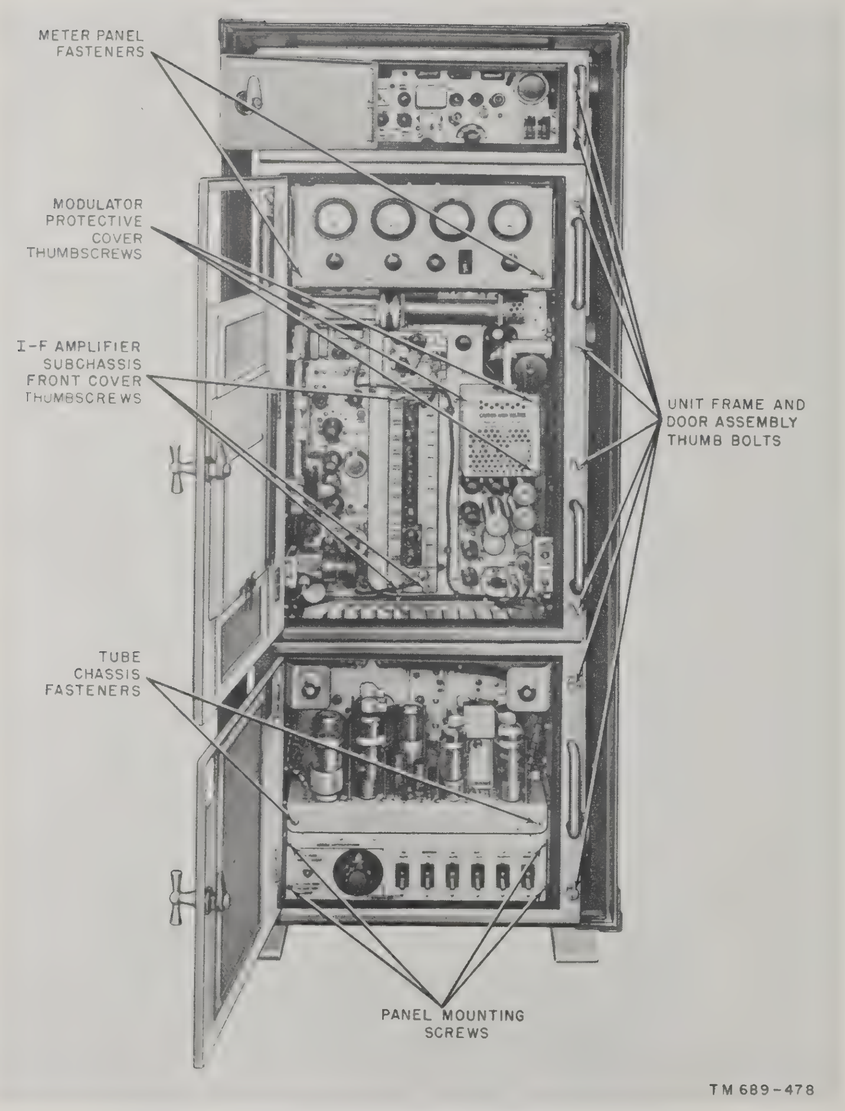

METER PANEL FASTENERS
MODULATOR PROTECTIVE COVER THUMBSCREWS
I-F AMPLIFIER SUBCHASSIS FRONT COVER THUMBSCREWS
TUBE CHASSIS FASTENERS
UNIT FRAME AND DOOR ASSEMBLY THUMB BOLTS
PANEL MOUNTING SCREWS
TM 689-478

Figure 358. Transmitter rack, front view showing location of mounting facilities.

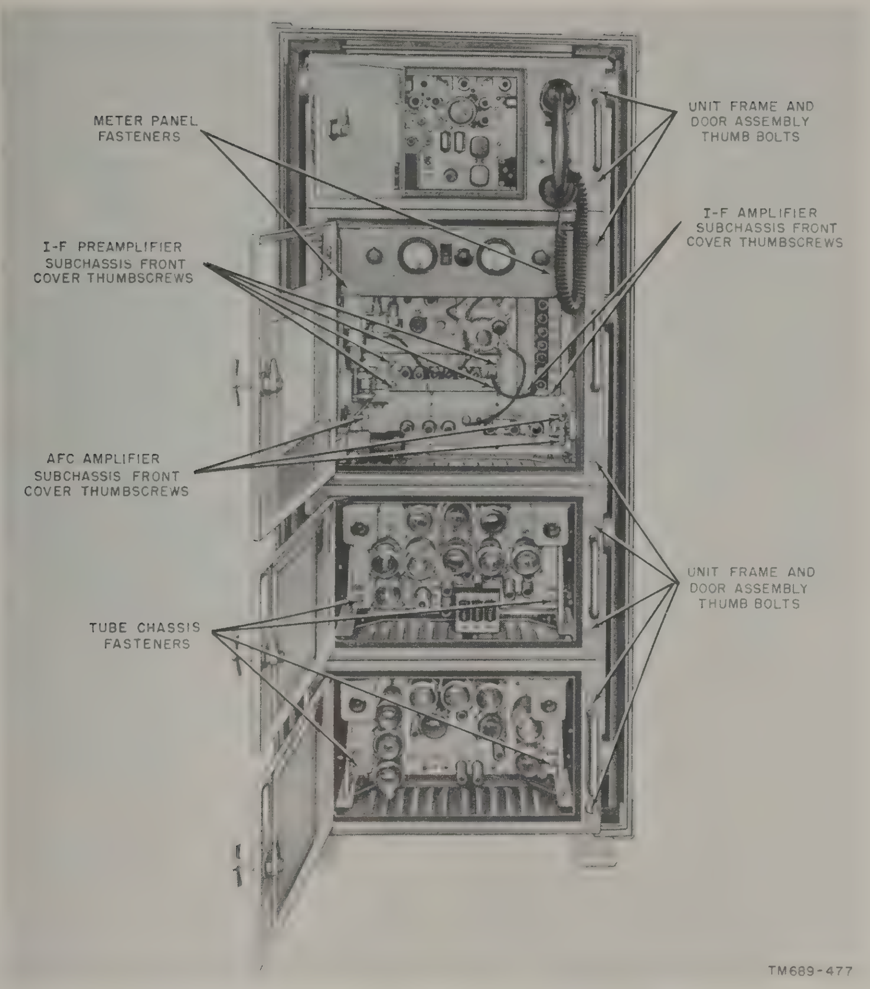

METER PANEL FASTENERS
UNIT FRAME AND DOOR ASSEMBLY THUMB BOLTS
I-F AMPLIFIER SUBCHASSIS FRONT COVER THUMBSCREWS
I-F PREAMPLIFIER SUBCHASSIS FRONT COVER THUMBSCREWS
AFC AMPLIFIER SUBCHASSIS FRONT COVER THUMBSCREWS
UNIT FRAME AND DOOR ASSEMBLY THUMB BOLTS
TUBE CHASSIS FASTENERS
TM689-477

Figure 359. Receiver rack, front view showing location of mounting facilities.

e. Replacement of Afc Motor. The afc motor is mounted on the radio transmitter main panel right front wall with its drive shaft coupled to the klystron fine tuning adjustment (fig. 10). To remove the afc motor, proceed as follows:

(1) Remove the four screws that hold the plastic cover.

(2) Remove the three leads from the microswitches.

(3) Hold the assembly in place and remove the three mounting screws located on the outside surface of the right wall of the transmitter.

(4) Tilt the assembly slightly and pull out. Do not twist the assembly when removing.

(5) Remove the motor from the detent cam by taking out the Allen screws that secure it.

Note. To reach all the Allen screws that mount the motor to the detent cam, it may be necessary to connect the motor to a 115-volt, ac source and operate the motor until the Allen screw is in position for removal. Refer to the schematic diagram (fig. 402) for correct connection of motor to ac source.

(6) Install the new motor by reversing the procedures outlined above.

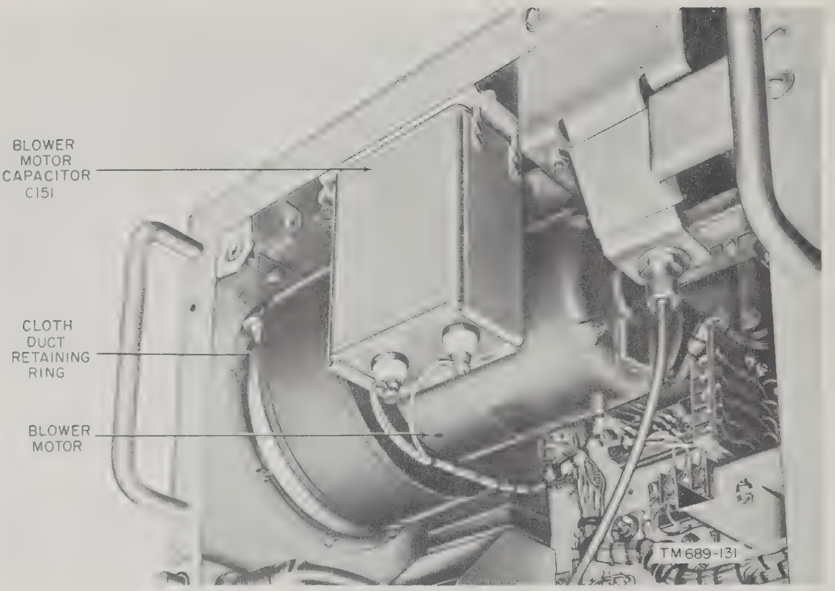


Figure 360. Blower motor assembly in place.

f. Replacement of Parts of Power Supply PP–764/G. To replace parts mounted on the bottom of the tube chassis (fig. 358), remove all interconnecting leads including the plate cap leads to V3 and V4. Loosen the fasteners that hold the chassis to the frame and remove the chassis. The circuit breakers and variable transformer can be replaced by first removing the screws that secure the panel to the frame and swinging down the panel. To gain access to the parts mounted to the rear of the power supply, remove the power supply from the rack and remove all covers as required. Note that the panels that mount the terminal boards and receptacles may be removed and swung away from the chassis (fig. 361).

g. Replacement of Parts of Order-Wire Receiver. For replacement of many parts of the order-wire receiver, remove the unit from the rack and take off the top, bottom, and side covers as required.

h. Replacement of Parts of Power Supply PP–690/G. To replace parts mounted on the bottom of the tube chassis (fig. 359), remove all interconnecting leads, loosen the fasteners that hold the chassis to the frame, and slide out the chassis. To replace the circuit breakers, remove the power supply from the rack and remove the two screws that secure the circuit breaker bracket to the bottom of the power supply chassis. The rear terminal board bracket can be removed by removing the four screws that secure it to the chassis. To replace L1, T1, or T2 located on the rear of the chassis, remove the mounting straps and the nuts that secure the mounting studs.

i. Replacement of Parts of Power Supply PP–689/G. To replace parts mounted on the bottom of the tube chassis (fig. 359), remove all interconnecting leads, loosen the fasteners that hold the chassis to the frame, and slide out the chassis. To gain access to the parts mounted in the rear of the power supply chassis, remove the unit from the rack.

230. Repair and Replacement of Radio Frequency Transmission Line Assembly CG–1013/U

If any component of the surface-wave transmission line assembly becomes defective, it should be replaced by a new component. Replacement of all parts of the launching units may be done at depot levels having replacement parts, proper tools, and cements.

Warning: Shut off all power before performing any repairs.

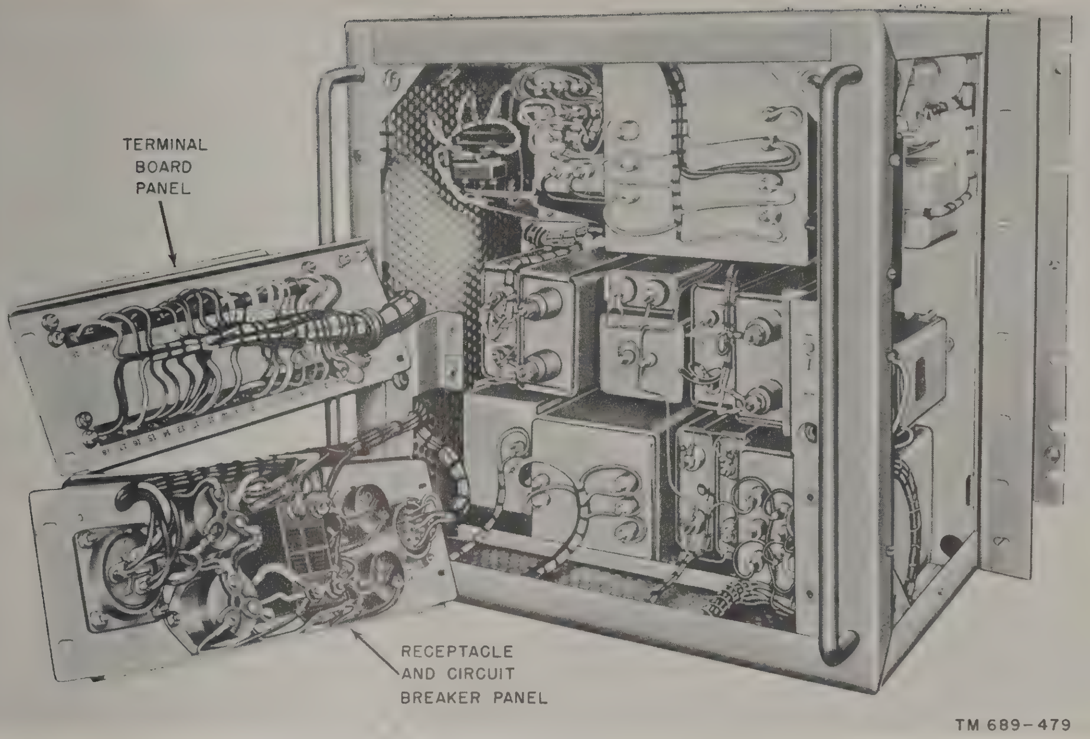


Figure 361. Power Supply PP-764/G, rear view with panels removed.

a. Transmission Line. To replace the transmission line, proceed as follows:

(1) Release the snubit clamp on the guy assembly and allow the guy wire to extend to its maximum length.

(2) Disconnect the rf and power cables from the upper launcher.

(3) Disconnect the launching unit mounting clevis from the tower strap and, using the hoist rope of the tower, carefully lower the launching unit to the ground.

(4) Remove the cone and shield from the housing of each launching unit (fig. 74).

(5) Remove the old transmission line from the connecting tip by prying the bent end of the transmission line from the hole in the connecting tip. Be careful not to break the tip.

(6) Cut off the bent end of the transmission line and pull the line through the hole in the end of the connecting tip and the shield.

(7) Replace the transmission line by following the procedure given in paragraph 50.

b. Launching Unit. To replace either launching unit, proceed as follows:

(1) Release the snubit clamp on the guy assembly and allow the guy wire to extend to its maximum length.

(2) Disconnect the launching unit mounting clevis from the tensioning spring if the lower launching unit is to be replaced.

(3) If the upper launching unit is to be replaced, disconnect the rf and power cables and the launcher unit mounting clevis and carefully lower the launching unit and transmission line to the ground using the tower hoist rope.

(4) Remove the transmission line from the defective launching unit (*a* above).

(5) Replace the transmission line in the new launching unit and install the launching unit by following the procedure given in paragraph 50.

c. Miscellaneous Parts of Transmission Line Assembly. Miscellaneous parts of the transmission line assembly are replaced as follows:

Note. Do not attempt replacement of parts of the upper launching unit with the unit attached to the tower. Always lower the launching unit to the ground before working on it.

(1) The cone and shield are replaced by removing the transmission line (*a* above) and unclipping the rope assembly at the housing.

(2) The connecting tip is replaced by removing the transmission line (*a* above) and unscrewing the tip from the connecting rod. Do not lose the lockwasher between the connecting tip and connecting rod.

(3) The connecting rod is replaced by removing the transmission line (*a* above), removing the connector assembly including the connecting pin that screws into the connecting rod, and unscrewing the connecting rod.

Note. Do not attempt housing repairs unless a full set of connector assembly repair parts are on hand. The insulating connection is cemented in place and will be damaged beyond reuse during disassembly.

(4) The housing is replaced by removing the connecting rod ((3) above) and removing the two setscrews that mount the housing to the mounting assembly.

d. De-icing Assembly. To replace the de-icing transformer, the current transformer, the ammeter, or the toggle switch in the de-icing assembly, it first must be removed from its case as follows:

(1) Remove the 22 bolts around the edge of its front panel.

(2) Lift the panel from its case.

(3) Disassemble the de-icing assembly as required.

Section III. ALINEMENT PROCEDURES

Note. This section contains the alinement procedures that cannot be performed with the internal metering and monitoring facilities provided in the radio set. Alinement or adjustment procedures that can be performed with the internal metering and monitoring facilities are given in chapter 2. (See pars. 65–72.)

231. Test Instruments Used for Alinement and Adjustment

a. Order-Wire Transmitter. The following test equipment is required for alining the order-wire transmitter:

(1) *Vtvm.* A vtvm, such as Electronic Multimeter TS–505/U, is required to provide a dc voltage range of 0 to +200 volts. The input impedance should be 1 megohm, or higher.

(2) *Ac vtvm.* An ac vtvm, such as Voltmeter ME–30A/U, is required to have a voltage range from 10 millivolts to 100 volts rms and an input impedance greater than 2 megohms.

(3) *Heterodyne frequency meter.* A heterodyne frequency meter, such as AN/URM–79, is required to measure frequency of 6-mc signal.

(4) *Signal generator.* A signal generator, such as Signal Generator TS–497A/URR, is required to have a frequency range of 5.9 to 6.1 mc, an output level of 0.1 volt, an output impedance of 50 ohms, and a 6-db isolation attenuator.

(5) *Oscilloscope.* An oscilloscope, such as AN/USM–24, is required to have the following characteristics: frequency response of 0 to 6 mc, and input impedance of 0.5 megohm or greater.

(6) *Audio oscillator.* An audio oscillator, such as Audio Oscillator TS–382/U, is required to have a frequency range of 10 cps to 30 kc and an output level variable from 0 to 2.5 volts.

b. Radio Transmitter. The following equipment is required for alining the radio transmitter:

(1) *Signal generator.* A signal generator, such as Signal Generator TS–497A/URR, is required to have a frequency range of 110 to 130 mc, an output level adjustable from 0 to 100 millivolts, an

output impedance of 50 ohms, and a 6-db isolation attenuator.

(2) *Sweep generator.* A sweep generator, such as SG–92/U, is required to have a center frequency of 120 mc, a deviation of ±15 mc, sawtooth sweep output, variable output level from 0 to 100 millivolts, and output impedance of 50 ohms.

(3) *Oscilloscope.* Same as oscilloscope listed in *a*(5) above.

(4) *Matching pad.* A 50- to 90-ohm (120 mc) matching pad is required. This matching pad can be made up as indicated in figure 362.

(5) *Vtvm.* Two vtvms, such as Electronic Multimeter TS–505/U, are required to have a frequency response to at least 6 mc and voltage ranges (ac and dc) from 0 to 40 volts.

(6) *Heterodyne frequency meter.* A heterodyne frequency meter, such as Frequency Meter AN/URM–81, is required to have a frequency of 100 to 140 mc and an accuracy of ±0.01 percent.

(7) *Coaxial cable.* Three feet of RG–58C/U cable with UG–88/U fittings are required.

(8) *Coaxial adapters.* Two UG–201/U and one UG-273/U coaxial adapters are required.

(9) *Alinement tool.* The alinement tool supplied in receiver rack is required.

(10) *Marker injection cable.* A special marker injection cable is required which can be made up as indicated in figure 363.

(11) *Audio oscillator.* Same as indicated in *a*(6) above.

(12) *Video signal generator.* A video signal generator, such as RF Signal Generator AN/URM–25D, is required to have a frequency range of 20 kc to 6 mc and output voltage continuously variable from 0 to 50 millivolts.

(13) *Video signal generator.* A video signal generator, such as Hewlett Packard model 650A, may be used instead of either or both of the instruments listed in (11) and (12) above.

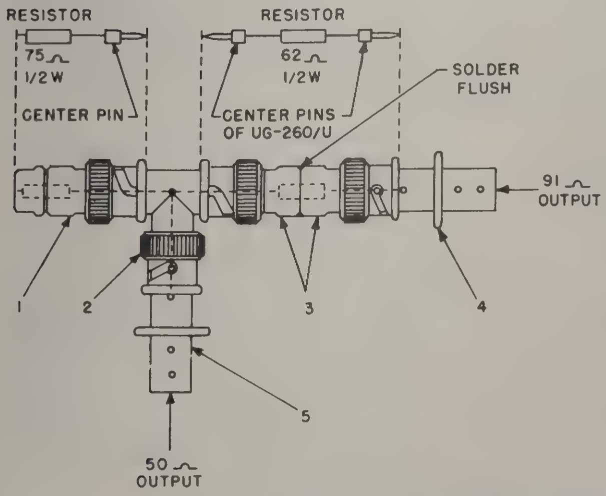
(14) *Multimeter.* A multimeter, such as Multimeter TS–352/U, is required to measure voltages to —2,500 volts.

c. Order-Wire Receiver. The following test equipment is required for alining the order-wire receiver:

(1) *Vtvm.* Same as vtvm listed in *a*(1) above.

(2) *Ac vtvm.* Same as ac vtvm listed in *a*(2) above.

(3) *Heterodyne frequency meter.* Same as heterodyne frequency meter listed in *a*(3) above.



NOTES:

1	MX-554/U BNC CONNECTOR	100Ω RESISTOR REMOVED AND 75Ω RESISTOR SOLDERED TO CENTER PIN OF FITTING. OTHER LEAD SOLDERED TO BASE.
2	UG-274/U BNC T CONNECTOR	
3	UG-260/U BNC MALE CONNECTORS	TWO BNC MALE CONNECTORS SOLDERED BACK TO BACK. 62Ω RESISTOR LEADS CUT TO LENGTH AND SOLDERED TO CENTER PIN OF FITTINGS.
4	UG-414/U	
5	UG-414/U	
	RESISTORS	COMPOSITION, ±5%, 1/2 W (VALUES MEASURED ON BRIDGE).

TM689-437

Figure 362. Matching pad for if. amplifier alinement.

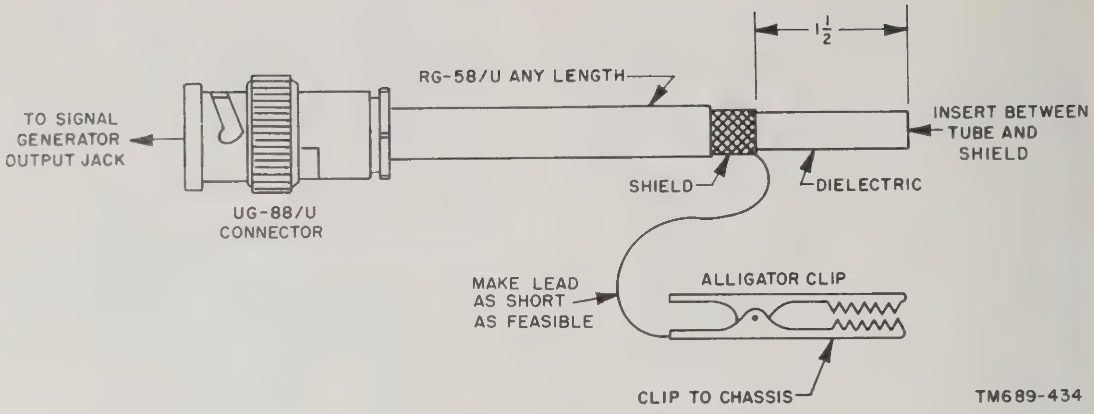

RG-58/U ANY LENGTH
1½
TO SIGNAL GENERATOR OUTPUT JACK
INSERT BETWEEN TUBE AND SHIELD
SHIELD
DIELECTRIC
UG-88/U CONNECTOR
MAKE LEAD AS SHORT AS FEASIBLE
ALLIGATOR CLIP
CLIP TO CHASSIS
TM689-434

Figure 363. Special marker injection cable.

(4) *Audio oscillator.* Same as audio oscillator listed in *a*(6) above.

(5) *Oscilloscope.* Same as oscilloscope listed in *a*(5) above.

d. Radio Receiver. The test equipment is listed in (1) through (5) below.

(1) *If. preamplifier (V1 to V6) alinement.* The following is a list of test equipment required for the if. preamplifier alinement:

(*a*) *Signal generator.* Same as signal generator listed in *b*(1) above.

(*b*) *Sweep generator.* Same as sweep generator listed in *b*(2) above.

(*c*) *Oscilloscope.* Same as oscilloscope listed in *a*(5) above.

(*d*) *Vtvm.* Same as vtvm listed in *b*(5) above.

(*e*) *Heterodyne frequency meter.* Same as heterodyne frequency meter list listed in *b*(6) above.

(*f*) *Coaxial cable.* Same as coaxial cable listed in *b*(7) above.

(*g*) *Alinement tool.* Same as alinement tool listed in *b*(9) above.

(*h*) *Coaxial adapters.* Same as coaxial adapters listed in *b*(8) above.

(*i*) *Marker injection cable.* A special marker injection cable must be made up as indicated in figure 363.

(*j*) *Crystal detector.* A special crystal detector must be made up as indicated in figure 364.

(*k*) *Equivalent mixer network.* A special equivalent mixer network must be made up as indicated in figure 365.

(2) *120-mc if. amplifier, limiter and discriminator.* Test equipment list required to aline the 120-mc if. amplifier, limiter, and discriminator is the same as items in *b*(1) through (10) above.

(3) *Afc if. amplifier and discriminator.* The following test equipment is required to aline the afc if. amplifier and discriminator:

(*a*) *Signal generator.* A signal generator, such as Signal Generator TS–497/URR, is required to have a frequency range of 30 to 39 mc, frequency accuracy of 1 percent, output impedance of 50 ohms, a calibrated and adjusted output level of 5 to 100 millivolts, and a 6-db isolating attenuator.

(*b*) *Heterodyne frequency meter.* A heterodyne frequency meter, such as AN/URM–80, is required to have a frequency of 34.5 mc, and an accuracy of ±0.05 percent.

(*c*) *Coaxial cables.* One coaxial cable, same as listed in *b*(7) above, and one 3-foot RG–58C/U cable with UG–88/U fitting at one end and the bared center conductor brought out at the other end.

(*d*) *Coaxial adapters.* One UG–201/U coaxial adapter and one UG–274/U adapter are required.

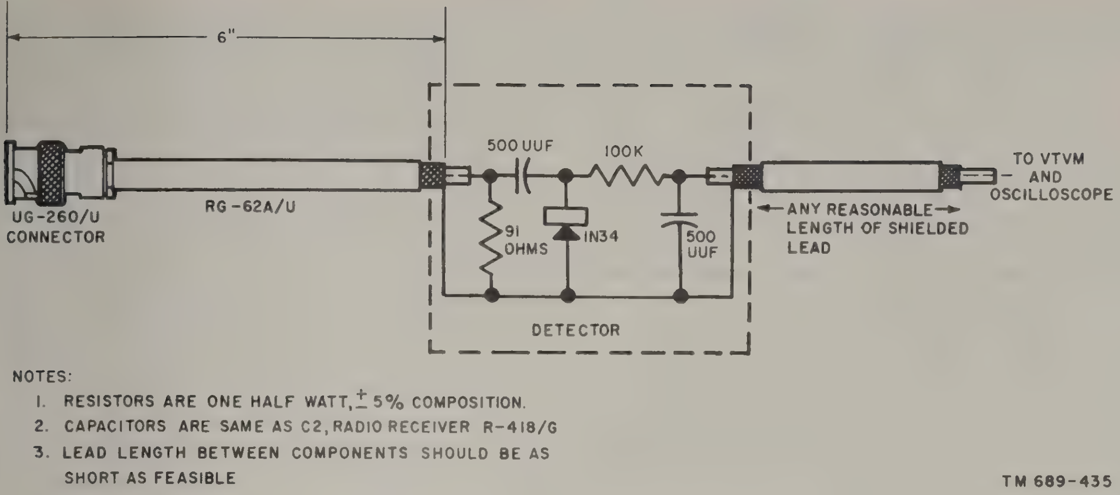

6"
500 UUF
100K
UG-260/U CONNECTOR
RG-62A/U
91 OHMS
IN34
500 UUF
DETECTOR
TO VTVM AND OSCILLOSCOPE
ANY REASONABLE LENGTH OF SHIELDED LEAD
NOTES:
1. RESISTORS ARE ONE HALF WATT, ± 5% COMPOSITION.
2. CAPACITORS ARE SAME AS C2, RADIO RECEIVER R-418/G
3. LEAD LENGTH BETWEEN COMPONENTS SHOULD BE AS SHORT AS FEASIBLE
TM 689-435

Figure 364. Special crystal detector.

(*e*) *Vtvm.* Same as vtvm listed in *b*(5) above.

(4) *Preselector and if. coupling coil.*

(*a*) *Rf signal generator.* An rf signal generator is required to provide a 200-millivolt output in the frequency range of 1,700 to 2,400 mc. Signal Generator AN/URM–64 can be used to cover the range of 1,700 to 2,100 mc and Signal Generator AN/URM–61 can be used to cover the range of 1,820 to 2,400 mc.

(*b*) *Rf isolating pad.* An rf isolating pad that consists of about 16 feet

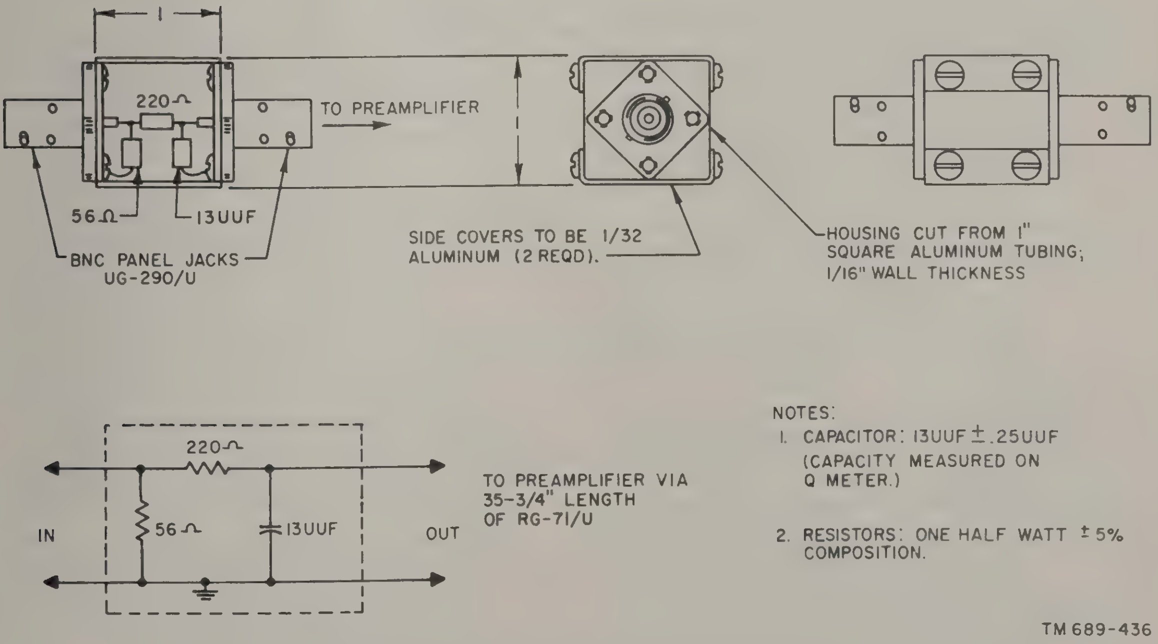

1
220Ω
TO PREAMPLIFIER
56Ω
13UUF
BNC PANEL JACKS UG-290/U
SIDE COVERS TO BE 1/32 ALUMINUM (2 REQD).
HOUSING CUT FROM 1" SQUARE ALUMINUM TUBING; 1/16" WALL THICKNESS
220Ω
IN
56Ω
13UUF
OUT
TO PREAMPLIFIER VIA 35-3/4" LENGTH OF RG-71/U
NOTES:
1. CAPACITOR: 13UUF ± .25UUF (CAPACITY MEASURED ON Q METER.)
2. RESISTORS: ONE HALF WATT ± 5% COMPOSITION.
TM 689-436

Figure 365. Special equivalent mixer network.

of RG–21/U is required to provide 10-db attenuation in the range of 1,700 to 2,400 mc.

(5) *Beam current adjustment.* To adjust the beam current, a multimeter, such as Electronic Multimeter TS–352/U, is required with a current range of 0 to 30 ma and an accuracy of 3 percent.

232. Order-Wire Transmitter Alinement and Adjustment

a. General. The order-wire transmitter is alined and adjusted as described in *b* through *e* below. When extensive repair of the order-wire transmitter has been performed, all the adjustment and alinement procedures described in *b* through *e* below should be made. However, if only a tube or other single component has been replaced, it is sufficient to adjust or aline only the circuit in which repair has been made. In each of these procedures it is assumed that power has been applied to the order-wire transmitter as described in paragraph 78*a*.

b. Power Supply Adjustment. The +140V ADJ control in the power supply is adjusted as follows:

(1) Vary INCREASE OUTPUT control on autotransformer for a LINE VOLTS meter reading on radio transmitter as close to 115 volts as possible.
(2) Place a vtvm across C35.
(3) Measure voltage across C35 with vtvm. If necessary, adjust +140V ADJ control for a meter reading of 140 volts.
(4) Measure ripple voltage across C35 with ac vtvm. It should be 50 millivolts or less.
(5) Vary INCREASE OUTPUT control on autotransformer for a LINE VOLTS meter reading of 105 volts. Ripple voltage should not exceed 70 millivolts.
(6) Readjust line voltage for 130 volts. Ripple voltage should not exceed 70 millivolts.
(7) If the values of ripple voltage indicated in (4) through (6) above are not obtained, readjust the +140V ADJ control slightly first in one direction and then the other until proper ripple voltages are obtained. However, do not vary the voltage by more than 5 volts.

c. Alinement of Discriminator. The discriminator is alined in the following manner:

(1) Place pickup loop from Frequency Meter AN/URM–79 near FREQ ADJ (L1) coil. Adjust FREQ ADJ for a zero beat at 6.000 mc. Place ORDER WIRE TEST SWITCH in AFC OFF position.
(2) Place the vtvm between the junction of R42 and C29 and ground.
(3) Adjust the primary and secondary coils of T3 for maximum negative dc voltage on the meter.
(4) Place the vtvm at the junction of R39 and R40 and adjust the primary of T2 for maximum negative dc voltage.
(5) Adjust the secondary of T2 for a zero meter reading at the junction of R38 and R39.
(6) Repeat (4) and (5) above until one adjustment does not affect the other.
(7) Readjust FREQ ADJ for 6.000 mc.
(8) Place ORDER WIRE TEST SWITCH in OPERATE position. If the oscillator frequency as noted on the AN/URM–79 shifts, readjust secondary of T2 for an oscillator frequency of 6.000 mc.
(9) Place ORDER WIRE TEST SWITCH in AFC OFF position. The oscillator frequency should not change by more than ±1 kc. If it does, repeat the alinement procedure.

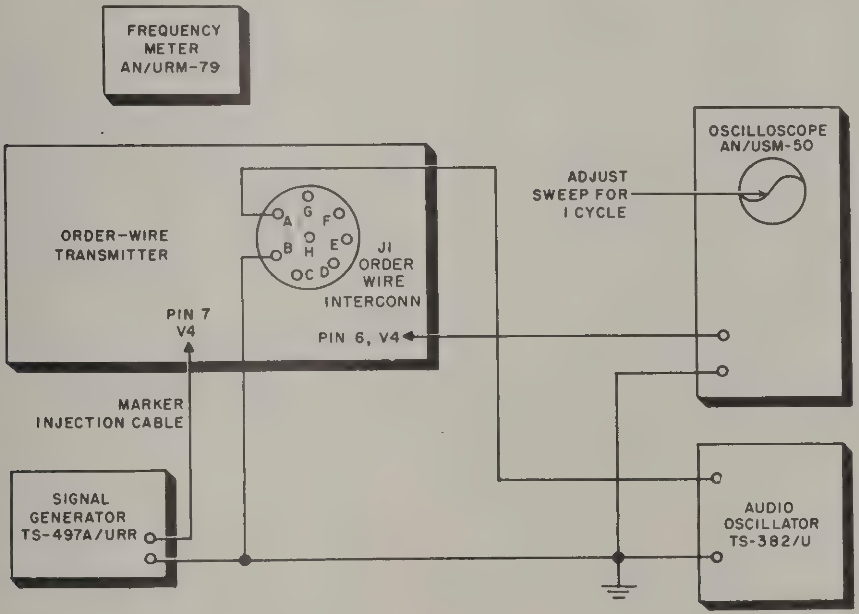
d. Alinement of Carrier Oscillator (fig. 366). The carrier oscillator is alined as follows:

(1) Disconnect the cable from ORDER WIRE INTERCONN jack (J1) and connect output of audio oscillator between pins A and B (fig. 366).
(2) Connect the oscilloscope signal lead to pin 6, V4. Connect the ground lead to the order-wire transmitter chassis.
(3) Connect the output of the signal generator to pin 7, V4. Set the generator output to zero.
(4) Adjust the audio oscillator frequency to approximately 1 kc and adjust its output level to 2.5 volts as read across its output terminal with the vtvm.
(5) Place the vtvm across pin 7 of V2 and

ground and adjust the AUDIO LEVEL THRU CHAN control for a reading of 0.3 volt rms.

(6) A series of sine waves should be displayed on the oscilloscope. Vary the sweep control until only 1 cycle is displayed as shown in the figure.

(7) Set the signal generator frequency to exactly 6.000 mc by use of the frequency meter, then increase the output slowly until a small pip appears on the scope. The pip should appear halfway between the maximum negative and maximum position voltages. If it does not, adjust the FREQ ADJ control until it does.


FREQUENCY METER AN/URM-79
ORDER-WIRE TRANSMITTER
A
G
F
B
H
E
C
D
J1 ORDER WIRE INTERCONN
PIN 7 V4
PIN 6, V4
MARKER INJECTION CABLE
SIGNAL GENERATOR TS-497A/URR
ADJUST SWEEP FOR 1 CYCLE
OSCILLOSCOPE AN/USM-50
AUDIO OSCILLATOR TS-382/U

TM 689-438

Figure 366. Crystal oscillator test setup.

(8) Set the signal generator frequency to exactly 5.950 mc using the frequency meter. The pip should appear at bottom of sine wave.

Caution: The signal generator output level should be kept to a minimum.

(9) Set the signal generator frequency to exactly 6.050 mc. The pip should appear at top of sine wave.

(10) Adjust the MOD SENS ADJ and FREQ ADJ controls until results indicated in (7) through (9) above are obtained; namely, pip appears that the center of the waveform (oscillator frequency) at 6.000 mc; at the bottom of the waveform at 6.050 mc; and at the top of the waveform at 5.950 mc.

(11) Disconnect the audio oscillator and measure the oscillator frequency with the frequency meter. It should be 6.000 mc. If it is not, repeat (10) above and this procedure until the reading is obtained.

e. Audio Stages Adjustments. The audio stages are adjusted as follows:

(1) Connect the audio oscillator to pins A and B. Adjust the audio oscillator frequency to 1,000 cps and the output level, as measured on the meter across the oscillator output terminals, to 0.776 volt rms.

(2) Place the ORDER WIRE TEST SWITCH in the OPR position.

(3) Place the vtvm at pin 7 of V2 and ad-

just the AUDIO LEVEL THRU CHANNEL control for a meter reading of 0.3 volt rms.

(4) Place the meter selector switch in the AUDIO position. Adjust the AUDIO METER SENS control for a reading of 100 on the front panel meter.

(5) Adjust the AUDIO LEVEL THRU CHANNEL control fully clockwise. The front panel meter reading should exceed 120.

(6) Readjust the AUDIO LEVEL THRU CHANNEL control for a meter reading of 100.

(7) Remove the audio oscillator connection from pin A and connect it to pin D.

(8) The front panel meter reading should exceed 120 with AUDIO LEVEL LOCAL INPUT control fully clockwise. Adjust the AUDIO LEVEL LOCAL INPUT control for a meter reading of 100.

(9) Place the ORDER WIRE TEST SWITCH in the INPUT AUDIO position. The front panel meter reading should be between 90 and 110.

(10) Place the ORDER WIRE TEST SWITCH in the LOCAL TONE position. The meter reading should be between 80 and 120.

(11) Place the ORDER WIRE TEST SWITCH in the THRU TONE position. The meter reading should be between 80 and 120. Return the ORDER WIRE TEST SWITCH to the OPR position.

233. Radio Transmitter Alinement and Adjustment

a. General. The radio transmitter is alined and adjusted as described in *b* through *h* below. When extensive repair of the radio transmitter has been performed, all of the adjustments and alinements described in this paragraph should be checked in the sequence listed below. However, if only one tube or other single component has been replaced, it is sufficient to check the adjustment or alinement of the circuit in which repair has been made. In each of these procedures, it is assumed that power has been applied to the radio transmitter as described in paragraph 77 and that all other circuits are operating and are calibrated properly. If the latter assumption cannot be made, check the adjustment or alinement of all circuits in question in the following sequence:

(1) Tuneup of crystal multiplier.
(2) Adjustment of vtvm.
(3) Adjustment of modulator.
(4) If. amplifier alinement.
(5) Adjustment of klystron voltage.
(6) Tuneup of klystron and power amplifier.
(7) Calibration of percent-modulation meter.
(8) Sawtooth output level adjustment.

b. Tuneup of Crystal Multiplier. Tune crystal multiplier as described in paragraph 76.

c. Adjustment of Vtvm. The vtvm is adjusted as follows:

(1) Place the VTVM SEL SW in GND position.

(2) Place the vtvm meter switch in POS PEAK position. Adjust the VTVM ZERO BALANCE POS control for a zero reading on PEAK VTVM.

(3) Place the vtvm meter switch in NEG PEAK position. Adjust the VTVM ZERO BALANCE NEG control for a zero reading on PEAK VTVM.

(4) Remove the protective cover on the modulator. Connect the vtvm between the junction of R52 and C25 and ground, the modulator output (fig. 367).

(5) Connect Audio Oscillator TS–382/U through a 560-ohm resistor to the VIDEO INPUT receptacle at the back of the radio transmitter.

(6) Connect another vtvm across output terminals of the signal generator.

(7) Adjust the audio oscillator frequency to 500 cps and adjust its output for a 1.2-volt reading on vtvm across its terminals. (This corresponds to a 0.1-volt modulator input.)

(8) Place the MOD SEL SW switch in VID position. The vtvm connected to modulator output should read about 44 volts rms.

(9) Adjust the audio oscillator so that the modulator output voltage is 35.4 volts rms.

(10) Place the VTVM SEL SW in the MOD

OUT position and adjust the VTVM SENS control so that PEAK VTVM meter reads exactly 50 on the black scale. Lock the VTVM SENS control in this position.

(11) Switch the vtvm meter selector switch from the NEG PEAK to the POS PEAK position. The meter reading should not change.

d. Modulator Adjustment. The modulator is adjusted as follows:

(1) Test equipment is connected to the transmitter in the same manner indicated in *c*(4) through (6) above.

(2) Adjust Audio Oscillator TS–382/U frequency to 10 cps and output level to 0.6 volt.

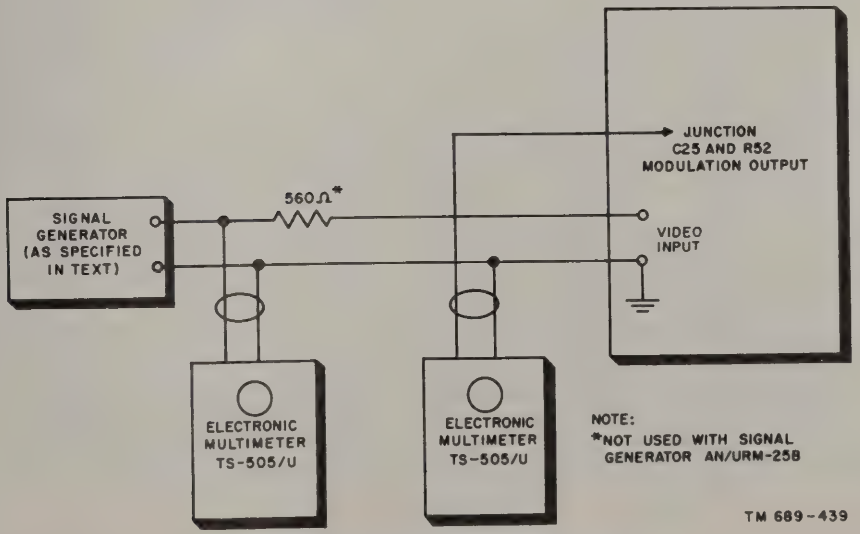
(3) Record the meter reading at the modulator output.

(4) Keeping the output level at 0.6 volt, repeat (3) above for the audio oscillator frequencies of 20 cps, 40 cps, 70 cps, 100 cps. 200 cps, 400 cps, 700 cps, 1,000 cps, 2,000 cps, 4,000 cps, 7,000 cps, 10 kc, and 20 kc. As the frequency is changed, watch the meter for peaks and dips that indicate undesirable resonances.

(5) Replace the TS–382/U with RF Signal Generator AN/URM–25D, removing the 560-ohm resistor so that the generator output is fed directly to the modulator input. Adjust the signal generator frequency to 20 kc and the output level to 0.05 volt on the output meter. Note the modulator output meter reading and compare it with 20-kc reading obtained in (4) above. Usually these two readings will be different because the signal distortion in each generator is different. Determine the difference factor between the two generators; then multiply each reading obtained with RF Signal Generator AN/URM–25D by this factor so that all readings are *normalized.*

(6) Keeping output level at 0.05 volt, repeat (3) above at signal frequencies of 40 kc, 70 kc, 100 kc, 200 kc, 400 kc, 700 kc, 1 mc, 2 mc, 3 mc, 4 mc, 4.5 mc, 5 mc, and 6 mc. Each time the frequency is changed, watch the meter for peaks and dips. Each time the signal generator is switched from one band to another, check the output voltage meter reading at a frequency that is common to both bands and then *normalize* meter reading by following procedure outline in (5) above.

(7) If a Hewlett-Packard Model 650A signal generator, or equivalent, is available the entire frequency response run can be made with this generator. In


JUNCTION
C25 AND R52
MODULATION OUTPUT
560Ω*
SIGNAL GENERATOR (AS SPECIFIED IN TEXT)
VIDEO INPUT
ELECTRONIC MULTIMETER TS-505/U
ELECTRONIC MULTIMETER TS-505/U
TM 689-439

NOTE:
*NOT USED WITH SIGNAL GENERATOR AN/URM-25B

Figure 367. Vtvm and modulator test setup.

this case, connect the signal generator to the modulator via the 560-ohm resistor and adjust the output for a vtvm meter reading of 1.2 volts (equal to 0.1 volt at modulator input) and check output of all frequencies indicated in (4) and (6) above with the signal generator output level maintained at 1.2 volts. Note that it is still necessary to normalize meter readings at 10 x 10K and 1 x 100K points.

Note. It should be noted that 0.1 rather than 0.05 volt is applied to the modulator as described above. Consequently, the readings obtained above are double those obtained in (3) and (5) above. Two sets of values are referenced in the following procedures and on the associated frequency response curves, one for a 0.05-volt input and the other for a 0.1-volt input.

(8) Plot the modulator output voltages obtained in (3) through (6) or (7) above as a response curve. Compare the curve obtained with the response curve shown in figure 368. As indicated in this curve, the output voltage should be substantially constant (within 0.5 volt out of 22 or 1 volt out of 44 volts) from 100 cps to 2.0 mc. There should be a smooth drop in voltage from 2.0 to 6.0 mc, and below 100 to 10 cps.

(9) Inspect the portion of the response curve from 1.0 to 4.5 mc. There should be a slight rise of about 0.25 or 0.5 volt from 1.0 to 2.0 mc, then a smooth drop to 4.5 mc. The level at 4.5 mc should be about 1.0 or 2.0 volts lower than that at 1.0 mc. If this is not true, adjust peaking coil L3 so that level at 4.5 mc is 1.0 or 2.0 volts lower than at 1.0 mc. Make sure that the signal generator output is maintained at 0.05 or 1.2 volts and that the vtvm is zeroed for each reading.

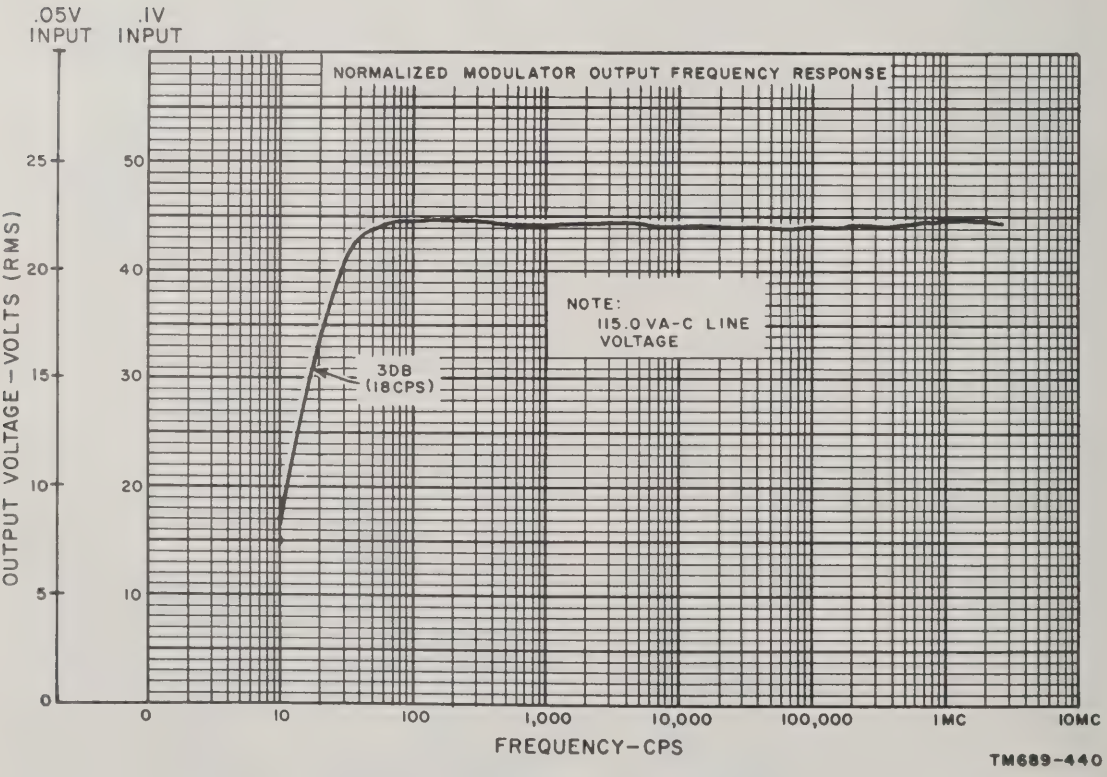


Figure 368. Modulator typical response curve.

e. If. Amplifier Alinement. The If. amplifier including limiters and discriminator, is alined as described in (1) through (8) below.

(1) *Modification of if. amplifier.* To aline the if. amplifier, the following modifications must be made:

(*a*) Place all circuit breakers in the transmitter in the OFF position.

(*b*) Solder a 91-ohm resistor between pin 1 of V13 and the chassis ground.

(*c*) Short coil L7 by connecting a bare, tinned, copper wire across it.

(2) *Preliminary if. alinement.* The if. amplifier is alined initially as follows:

(*a*) Connect the signal generator through its isolation pad to the matching pad (50-ohm side) with the 3-foot coaxial cable (fig. 369).

(*b*) Disconnect the if. amplifier input cable from the mixer and connect the input cable to the matching pad (91-ohm side).

(*c*) Connect the vtvm probe to terminal 4 of fanning strip (1st limiter grid).

(*d*) Set the signal generator output at a minimum, and apply low-voltage power to transmitter rack as described in paragraph 76*a*. Allow a 10-minute warmup period.

(*e*) Set the signal generator frequency to 120 mc and increase the output level of generator until a meter reading of 2.2 volts dc is obtained.

(*f*) Using the alinement tool, adjust L19 until the meter reads a maximum. While adjusting L19, reduce the generator level so that the meter reading stays at 2.2 volts.

(*g*) With the signal generator tuned to 110.5 mc, repeat the procedure outlined in (*f*) above for L17.

(*h*) With the signal generator tuned to 130.5 mc, repeat the procedure outlined in (*f*) above for L15.

(*i*) With the signal generator tuned to 110.5 mc, repeat the procedure outlined in (*f*) above for L13.

(*j*) With the signal generator tuned to 120 mc, repeat the procedure outlined in (*f*) above for L11.

(*k*) With the signal generator tuned to 130.5 mc, repeat the procedure outlined in (*f*) above for L9.

(3) *Preliminary limiter alinement.* The first and second limiters are alined initially as follows:

(*a*) Substitute the sweep generator for the signal generator and connect terminal 4 to oscilloscope (fig. 369), in parallel with the meter. Connect

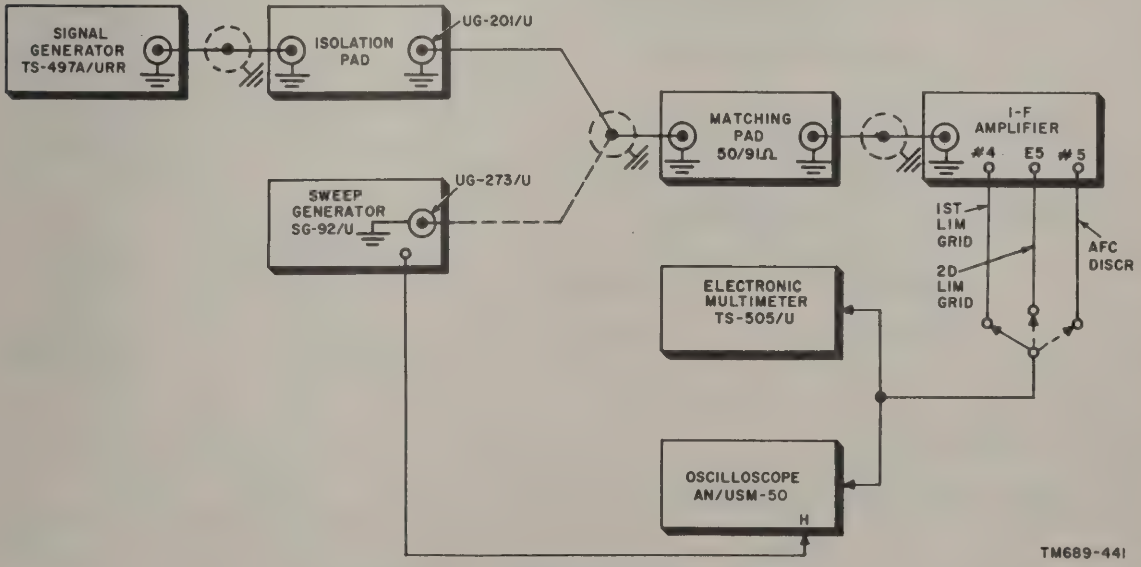


Figure 369. If. amplifier alinement test setup.

the synchronizing cable between the oscilloscope and sweep generator.

(*b*) With the sweep voltage at zero, set the generator center frequency to 120 mc.

(*c*) Adjust the output attenuator on the sweep generator for a 2.2- volt dc reading on meter.

(*d*) Set the sweep voltage on the generator to maximum deviation. A response should now appear on the oscilloscope.

(*e*) Reduce the sweep voltage so that only top 30 percent of the response amplitude is visible on the oscilloscope as illustrated in A, figure 370.

(*f*) Adjust the center frequency of the sweep generator so that ends of the response terminate on the same horizontal line on the oscilloscope screen (A, fig. 370).

(*g*) Remove the top cover of the amplifier chassis.

(*h*) Connect the oscilloscope and vtvm to test point E5, second limiter grid (fig. 369).

(*i*) Tune limiter coils L21 and L22 for maximum reading on the vtvm.

(*j*) Adjust L22 so that peaks of the response waveform on the oscilloscope are equal.

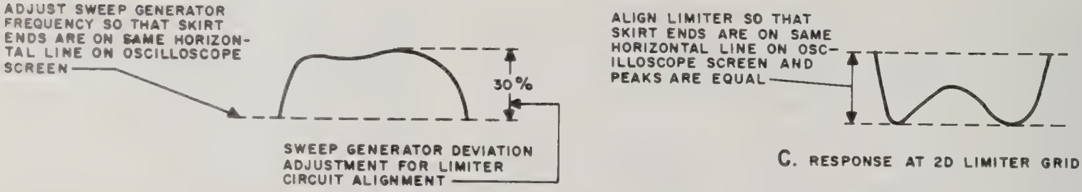
(*k*) Adjust L21 so that the ends of the response waveform terminate on the same horizontal line of the oscilloscope (C, fig. 370).

(*l*) Repeat (*j*) and (*k*) above. Because of interaction between L22 and L21, it may be necessary to repeat these procedures several times before a response like the one shown in C, figure 370, is obtained.

(4) *Preliminary discriminator alinement.* The discriminator is initially alined as follows:

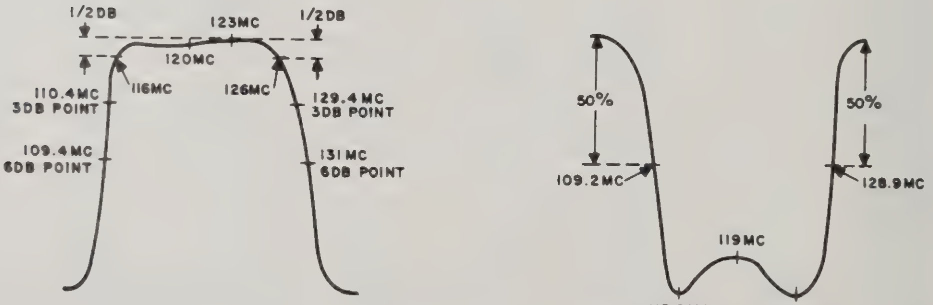
(*a*) Substitute the signal generator for the sweep generator (fig. 369).

(*b*) Connect the vtvm to terminal 4 of the fanning strip, tune the signal


ADJUST SWEEP GENERATOR FREQUENCY SO THAT SKIRT ENDS ARE ON SAME HORIZONTAL LINE ON OSCILLOSCOPE SCREEN
30%
SWEEP GENERATOR DEVIATION ADJUSTMENT FOR LIMITER CIRCUIT ALIGNMENT
ALIGN LIMITER SO THAT SKIRT ENDS ARE ON SAME HORIZONTAL LINE ON OSCILLOSCOPE SCREEN AND PEAKS ARE EQUAL

C. RESPONSE AT 2D LIMITER GRID

A. RESPONSE AT 1ST LIMITER GRID


1/2DB
123MC
1/2DB
120MC
116MC
126MC
110.4MC 3DB POINT
129.4MC 3DB POINT
109.4MC 6DB POINT
131MC 6DB POINT
50%
50%
109.2MC
128.9MC
119MC
113.8MC
125.8MC

B. I-F RESPONSE MEASURED AT 1ST LIMITER GRID

D. I-F RESPONSE MEASURED AT 2D LIMITER GRID

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Figure 370. Response waveshapes of if. amplifier.

generator to 120 mc, and set its output level for a 2.2-volt reading on the vtvm.

(*c*) Connect the vtvm to terminal 5, afc discriminator output, and tune L25 for maximum voltage on the meter.

(*d*) Connect the vtvm to terminal 4 of the fanning strip, tune the signal generator to 108 mc, and set its output level for a 2.2-volt reading on the meter.

(*e*) Connect the vtvm to terminal 5 of the fanning strip and tune L26 for maximum negative voltage on the meter.

(*f*) Tune the generator to 141 mc and set its output level for maximum output.

(*g*) Tune L27 for a maximum positive voltage on meter.

(*h*) Repeat the procedures outlined in (*d*) through (*g*) above until there is no reaction between tuning of L26 and L27.

(*i*) Zero the vtvm on its 2-volt range. Connect it to terminal 5.

(*j*) Slowly tune the generator about 120 mc until the vtvm reads zero.

(*k*) Disconnect the signal generator from the if. amplifier input cable and connect it to the frequency meter as indicated in figure 371.

(*l*) With the frequency meter, determine the exact frequency of the signal generator set in (*j*) above.

(*m*) Calibrate the signal generator dial at frequencies of 115, 120, and 125 mc, and record the dial readings. These calibration points will be used in setting generator frequency for the remainder of the alinement.

(*n*) Reconnect the signal generator to if. amplifier and set the generator to 120 mc.

(*o*) Set the signal generator level for 2.2 volts at terminal 4.

(*p*) If the discriminator *zero* frequency determined in (*j*) above was below 120 mc, rotate tuning screws on L26 and L27 equal increments in a counterclockwise direction until the vtvm, connected to terminal 5, reads exactly zero. Total rotation should not be more than 1½ turns, otherwise the discriminator alinement should be repeated.

(*q*) If the discriminator frequency in (*j*) above was above 120 mc, rotate the tuning screws on L26 and L27 equal increments in a clockwise direction until the vtvm, connected to terminal 5, reads exactly zero.

(*r*) Set the signal generator frequency

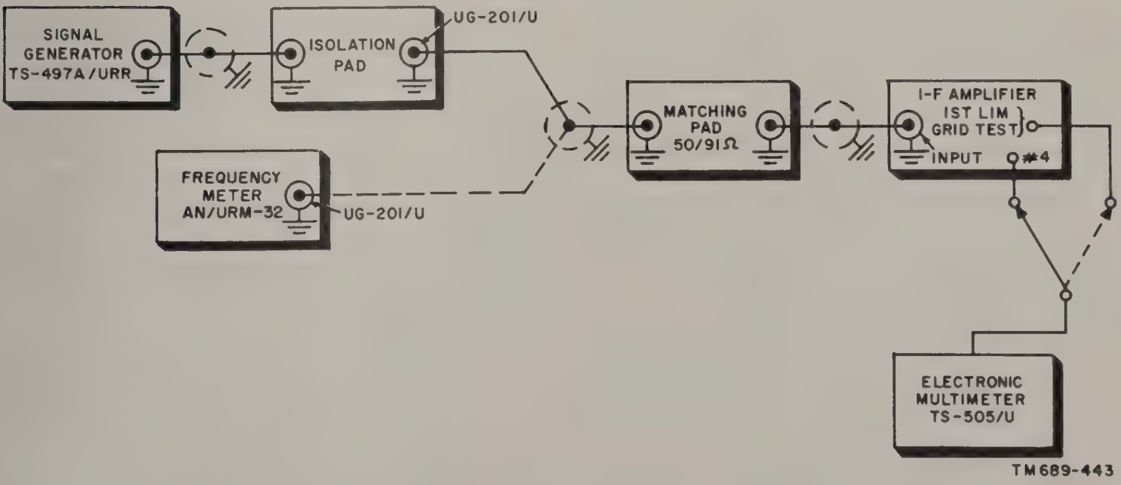


Figure 371. Discriminator alinement and sensitivity test setup.

to 115 mc and adjust its level for 2.2 volts at terminal 4.

(*s*) Measure the negative voltage at terminal 5.

(*t*) Set the signal generator frequency to 125 mc and the output level to 2.2 volts at terminal 4.

(*u*) Measure the positive voltage at terminal 5.

(*v*) Compare the discriminator voltages obtained in (*s*) and (*u*) above.

(*w*) Set the signal generator to frequency corresponding to the lower of the two values obtained in (*s*) and (*u*) above and adjust the generator level for a 2.2-volt reading at terminal 4.

(*x*) Set the meter to the proper range, zero the meter, and connect it to terminal 5.

(*y*) Adjust L25 so that lower discriminator voltage is equal to higher voltage.

(*z*) If necessary, repeat the procedures in (*r*) through (*y*) above until the outputs from the discriminator are equal.

(5) *Final alinement of limiter.* The final alinement of the limiter is performed as follows:

(*a*) Connect the sweep generator to the matching pad and vtvm and oscilloscope to terminal 4 as shown in figure 369.

(*b*) Repeat the procedures in (3) (*a*) through (*f*) above.

(*c*) Repeat the procedures in (3) (*h*) through (*l*) above.

(6) *Final if. amplifier alinement.* The final alinement of the if. amplifier is performed as follows:

(*a*) Connect the signal generator to the matching pad and the vtvm to terminal 4.

(*b*) Repeat the procedures in (2)(*e*) through (*k*) above.

(7) *Final discriminator alinement.* The final discriminator alinement is performed as follows:

(*a*) Connect the signal generator to the matching pad as shown in figure 371.

(*b*) Measure the discriminator output voltages at 115 and 125 mc by repeating the procedures in (4)(*r*) through (*u*) above, making sure to zero set the vtvm.

(*c*) If voltages are unequal, repeat the procedures in (4)(*w*) through (*z*) above.

(*d*) Measure the discriminator *zero* frequency by repeating the procedures in (4)(*i*) through (*l*) above.

(*e*) If the discriminator *zero* frequency is not within 100 kc of 120 mc, repeat the preliminary discriminator alinement procedure given in (4) above.

(8) *Removal of modifications.* Unsolder the 91-ohm resistor and shorting wire connected in (1)(*b*) above.

f. Adjustment of Klystron Voltage. Adjust the klystron voltage as follows:

(1) Apply the klystron voltage as described in paragraph 77 *b*(1) through (5).

(2) Place the POWER switch to OFF position. Connect Multimeter TS–352/U between terminal 10 of TB9 and ground. (Use the negative voltage scale with the voltage range exceeding 2,000 volts.) Place POWER switch ON and allow a few minutes for a warmup period.

(3) Adjust the REFL VOLTS SUPPLY ADJ control for a reading of —2,000 volts.

(4) Turn off the power and disconnect meter. Turn on the power again.

g. Tuneup of Klystron and Power Amplifier. Tune the klystron and power amplifier as described in paragraph 77.

h. Calibration of Percent Modulation Meter. The VIDEO LEVEL control on the if. amplifier subassembly is adjusted to provide a 100 percent PEAK VTVM meter reading when the klystron is 100 percent modulated in the following manner:

(1) Connect the output of Audio Oscillator TS–382/U through a 560-ohm resistor to VIDEO INPUT jack of the radio transmitter (fig. 372).

(2) Connect a 50-ohm load resistor across MON REC OUTPUT jack in place of the terminating fitting.

(3) Connect the signal input terminals of the oscilloscope across MON REC OUTPUT load resistor.

(4) Connect the output of Signal Generator TS–497A/URR through a marker cable to the if. amplifier. The if. amplifier end of the marker cable should be inserted between the shield and tube of V13. Set the output level of this signal generator to zero.

(5) Make sure that the vtvm is zeroed and the klystron and power amplifier are tuned properly.

(6) Set the audio oscillator to 500 cps.

(7) Place MOD SEL SW to the VIDEO position and VTVM SEL SW to the MOD OUT position.

(8) Adjust the VIDEO LEVEL control to about 75 percent of its maximum clockwise rotation.

(9) A sine wave should appear on the oscilloscope. Adjust the sweep control on the oscilloscope so that 1 cycle fills the screen of the cathode-ray tube horizontally, and adjust the vertical gain for a peak-to-peak height of three fourths of the screen.

(10) Set the signal generator to about 122 mc. Increase the output of this signal generator until a pip appears on oscilloscope.

Caution: In this procedure and in all succeeding procedures, the signal generator output should be set to the minimum value that will make a pip visible.

(11) Set the signal generator to 123.6 mc and adjust the level of the audio oscillator until the marker pip coincides exactly with the center of a peak of the sine wave.

(12) Set the signal generator to 116.4 mc. The marker pip should move to the other peak and end directly at its center. If it does not, adjust the level of the audio oscillator so that the frequency spread, as determined by the marker, between the two peaks is exactly 7.2 mc. To facilitate the exact location of the center of the sine wave

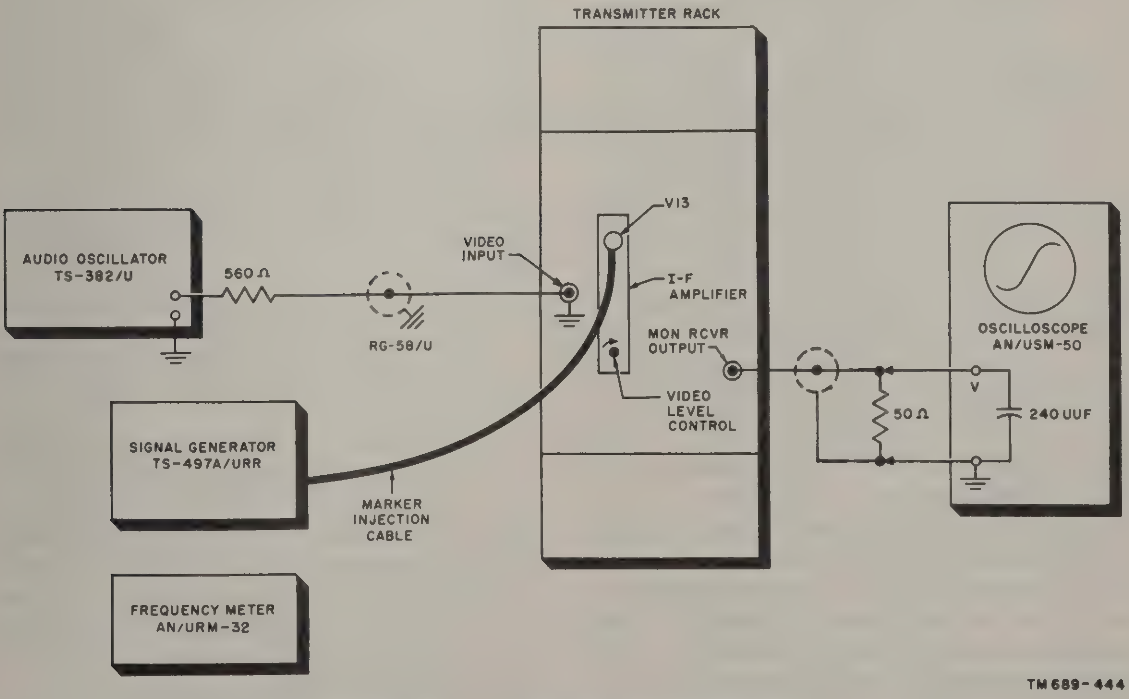

TRANSMITTER RACK
V13
VIDEO INPUT
I-F AMPLIFIER
AUDIO OSCILLATOR TS-382/U
560 Ω
RG-58/U
MON RCVR OUTPUT
VIDEO LEVEL CONTROL
OSCILLOSCOPE AN/USM-50
V
50 Ω
240 UUF
SIGNAL GENERATOR TS-497A/URR
MARKER INJECTION CABLE
FREQUENCY METER AN/URM-32
TM 689-444

Figure 372. Test setup for percent modulation calibration.

peaks, the horizontal gain of the scope should be reduced so that the cycle is compressed.

(13) Adjust the VIDEO LEVEL control for a PEAK VTVM reading of exactly 100 percent. Switch from POS PEAK to the NEG PEAK position or vice versa. The reading should be almost equal.

(14) Perform the procedures in paragraph 77*b*(49 and 50) (minimum deviation sensitivity adjustment).

(15) Repeat the procedures in (9) through (13) above. However, in this case, the frequency spread of 7.2 mc should be determined accurately with the frequency meter.

i. Sawtooth Output Level Adjustment. The sawtooth generator output is adjusted as follows:

(1) Equipment should be adjusted as described in *h* above.

(2) Connect the oscilloscope across 50-ohm MON REC OUT terminating resistor.

(3) Adjust the oscilloscope so that a few cycles of the video modulating frequency are shown. Mark the peak-to-peak amplitude of the sine wave on the face of the scope.

(4) Place MOD SEL SW in ST position.

(5) Readjust the sweep rate of the oscilloscope so that a few cycles of sawtooth test signal are displayed. (Repetition rate of sawtooth is about 500 cps.)

(6) Adjust the ST LEVEL control for a peak-to-peak amplitude reading equal to that marked on the scope in (3) above.

(7) Check the PEAK VTVM meter reading. In the NEG PEAK position, it should be about 110 percent and in POS PEAK position, about 85 percent.

234. Order-Wire Receiver Alinement and Adjustment

a. General. The order-wire receiver is alined and adjusted as described in *b* through *f* below. When extensive repair of the order-wire receiver has been performed, all the adjustment and alinement procedures described in this paragraph should be made. However, if only a tube or other single component has been replaced, it is sufficient to adjust or aline only the circuit in which repair has been made. In each of these procedures it is assumed that power has been applied to the order-wire receiver as described in paragraph 84*a*.

b. Power Supply Adjustment. The +140V ADJ control in the power supply is adjusted as follows:

(1) Vary the INCREASE OUTPUT control on the autotransformer for a LINE VOLTS meter reading on the radio transmitter as close as possible to 115 volts.

(2) Measure the voltage across C26B with the vtvm and adjust the +140V ADJ control for a meter reading of 140 volts.

(3) Check the ripple voltage across C26B with ac vtvm. Ripple should be less than 50 mv.

(4) Vary the line voltage to 103.5 volts and check the ripple voltage. It should be less than 70 mv.

(5) Vary the line voltage to 126.5 and check the ripple voltage. It should be less than 70 mv.

(6) If the ripple voltage does exceed 50 mv in (4) and (5) above or 20 mv in (3) above, vary the +140V ADJ control slightly and recheck the ripple voltages. Repeat this procedure until proper values are obtained. However, do not vary the +140 volts by more than ±5 volts.

c. Tuneup of Carrier Amplifier and Limiters. Tune the carrier amplifiers and limiters as follows:

(1) Disconnect all connecting cables from the back of the order-wire receiver.

(2) Connect the cable from the LOW PASS FILTER INPUT to OW CARR FILTER OUTPUT.

(3) Connect the output of an order-wire transmitter obtained at the ORDER WIRE CARR OUTPUT receptacle to the VIDEO INPUT FROM REC jack of the order-wire receiver being tuned.

(4) Using the frequency meter, determine that the output frequency of the order-wire transmitter is exactly 6.000 mc (unmodulated).

(5) Using an oscilloscope to measure the output level of the order-wire trans-

mitter, vary the ORDER WIRE CARR LEVEL control for an output of 50 millivolts rms.

(6) Place the oscilloscope at pin 1 of V1 and adjust C5 for maximum oscilloscope indication.

(7) If L3 has been replaced, place the oscilloscope across VIDEO OUT jack terminated in a 50-ohm resistor. Adjust L3 by varying the spacing between turns for minimum output.

(8) Place the oscilloscope at pin 1 of V2 and adjust the primary and secondary of T1 for maximum indication.

(9) Place the oscilloscope at pin 1 of V3 and adjust the primary and secondary of T2 for maximum indication.

(10) Place the oscilloscope at pin 1 of V4 and adjust the primary and secondary of T3 for maximum indication.

(11) Place the vtvm at junction of R14 and C14 and readjust C5, T1, and T2 for maximum negative meter reading.

(12) Place the vtvm at junction of R17 and R18 and readjust R3 for maximum negative meter reading.

d. Tuneup of Discriminator. Tune the discriminator as follows:

(1) Connect equipment as described in *c*(1) through (5) above.

(2) Connect the vtvm at junction of R22 and R23. Adjust the primary of T4 for maximum meter reading.

(3) Connect the vtvm (after zeroing it) to the junction of R22 and R24. Adjust the secondary of T4 for a zero reading.

(4) Repeat the procedures in (2) and (3) above until one adjustment does not affect the other.

e. Adjustment of Audio Circuits. The audio circuits are adjusted as follows:

(1) Connect equipment as described in *c*(1) through (5) above.

(2) Place ORDER WIRE TEST SWITCH in the order-wire transmitter to THRU TONE position. Adjust AUDIO LEVEL THRU CHANNEL control for AUDIO meter reading of 100.

(3) Place the vtvm at pin K of REPEATER INTERCONN jack and adjust AUDIO LEVEL control for a meter reading of 0.776 volt rms.

f. Other Adjustments. In addition to the adjustments described above, the order-wire receiver should be adjusted as follows:

(1) Adjust the order-wire receiver as described in paragraph 84.

(2) When used for diversity, adjust the unit as described in paragraph 93.

235. Radio Receiver Alinement and Adjustment

The circuits in the radio receiver that require alinement or adjustment are listed below. When extensive repair of the radio receiver has been performed, all of the adjustment and alinement procedures listed below should be checked, and adjusted or alined if necessary. However, if only a tube or other single component has been replaced, it is sufficient to adjust or aline only the circuit in which repair has been made. In each of these procedures, unless indicated to the contrary, it is assumed that power has been applied to the radio receiver as described in paragraphs 80*a* and 81*b*. Listed below are all of the radio receiver alinement and adjustment procedures in the sequence in which they should be performed when more than one circuit must be alined or adjusted.

a. Preamplifier (V1–V6). The alinement of the preamplifier is described in paragraph 236.

b. 120-mc If. Amplifier, Limiter, and Discriminator. The alinement of the 120-mc if. amplifier (V7–V12), limiters (V13 and V14), and discriminator (V15) is described in paragraph 237.

c. Crystal Multiplier (V22–V24). The crystal multiplier is tuned as described in paragraph 80*b*. If stage V22 has been repaired, the neutralizing coil, L44 must be adjusted as follows:

(1) Aline the crystal multiplier to channel 14 as described in paragraph 80*b*.

(2) Place the POWER switch in the OFF position.

(3) Remove the crystal and afc chassis front cover.

(4) Connect the vtvm to terminal 2 of the fanning strip.

(5) Place the POWER switch in the ON position. Allow a 10-minute warmup period.

(6) Turn the neutralizing coil, L44, fully counterclockwise.

(7) Turn the neutralizing coil clockwise until the vtvm reading goes to zero or a minimum.

(8) Reinsert the channel 14 crystal.

(9) Turn the 1ST MULT GRID control counterclockwise until the vtvm reading is a minimum, and then clockwise, and watch the vtvm for peak readings. Either a single or a double peak may be observed. If a single peak is observed, proceed to the procedure (11) below. If a double peak is observed, proceed to the procedure in (10) below.

(10) Turn the neutralizing coil, L44, clockwise in 1-revolution increments, repeating the procedure in (9) above after each increment until only a single peak is observed.

(11) Turn the POWER switch to the OFF position and replace the afc subchassis cover.

(12) Remove channel 14 crystal and replace it with the assigned channel crystal.

(13) Aline the crystal multiplier to the assigned channel.

d. Afc If. Amplifier and Discriminator. The alinement of the afc if. amplifiers (V25-V27) and discriminators (CR4 and CR5) is described in paragraph 238.

e. Beam Current Adjustment. The procedure for adjusting the beam current is given in paragraph 239.

f. Local Oscillator. After trouble is corrected in the local oscillator, it should be possible to tune it to 1,698 mc and 2,523 mc at a line voltage of 115 volts in accordance with the procedure outlined in paragraph 81. After the local oscillator tuning range is checked, the oscillator should be tuned to the desired channel frequency in accordance with the procedure outlined in paragraph 83.

g. Preselector and If. Coupling Coil. The alinement of the preselector and if. coupling coil is described in paragraph 240. This procedure also determines if the local oscillator, preamplifier, and if. amplifier are alined properly.

236. Preamplifier (V1–V6) Alinement

The preamplifier is alined in the following manner:

a. Turn the power off and remove the bottom cover of the preamplifier.

b. Connect a 51-ohm resistor across L4 and the jumper across L3 as shown in figure 373. Keep the lead lengths as short as possible.

c. Replace the bottom of the preamplifier.

d. Apply low-voltage power to the radio receiver as described in paragraph 80. Allow a 10-minute warmup period.

e. Connect the signal generator through the isolating pad and the 3-foot cable to the frequency meter as indicated via dotted line in figure 374.

f. Calibrate the signal generator signal frequencies from 100 to 140 mc. This calibration should be used for setting the generator frequencies for the remainder of the alinement procedure.

g. Disconnect the frequency meter from the 3-foot cable and the preamplifier input cable from the mixer assembly. Connect the 3-foot cable to the preamplifier (fig. 374).

h. Connect the crystal detector, vtvm, and oscilloscope to the preamplifier output as indicated in figure 374. Connect a synchronizing lead between the sweep generator and oscilloscope.

i. Tune the signal generator to 120 mc and adjust its output level so that the vtvm reads 0.5-volt dc.

j. Tune L19 for a maximum reading on the vtvm. While tuning L19, reduce the signal generator output so that the meter reading stays at 0.5 volt.

k. Repeat the procedure in *j* above for L17.

l. With the signal generator tuned to 110.5 mc, repeat the procedure in *j* above for L15.

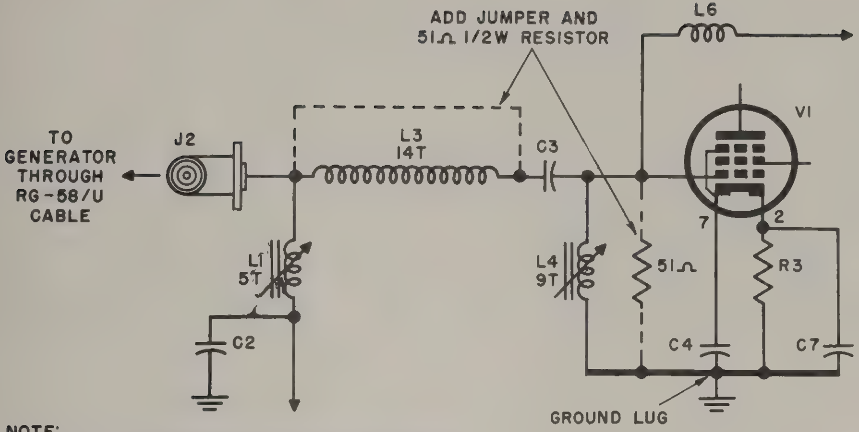
m. With the signal generator tuned to 130.5 mc, repeat the procedure in *j* above for L13.

n. With the signal generator tuned to 120 mc, repeat the procedure in *j* above for L7.

o. Repeat the procedures in *i* through *n* above.

p. Disconnect the signal generator from the isolation pad and connect the sweep generator to the isolation pad.

q. With the sweep voltage set to the zero deviation, adjust the center frequency of the sweep generator to approximately 120 mc.


ADD JUMPER AND
51Ω 1/2W RESISTOR
L6
VI
TO
GENERATOR
THROUGH
RG-58/U
CABLE
J2
L3
14T
C3
L1
5T
L4
9T
51Ω
7
2
R3
C2
C4
C7
GROUND LUG

NOTE:
FOR RADIO RECEIVER R-418/G ON ORDER NO. 1640-PHILA-51 (SERIAL NO. 13 THROUGH 247) AND ORDER NO. 15739-PHILA-55 (SERIAL NO. 298 THROUGH 417), L1, L3 AND L4 ARE:

L1	3½	TURNS
L3	13	TURNS
L4	7	TURNS

TM689-445

Figure 373. Modification of if. preamplifier for alinement.

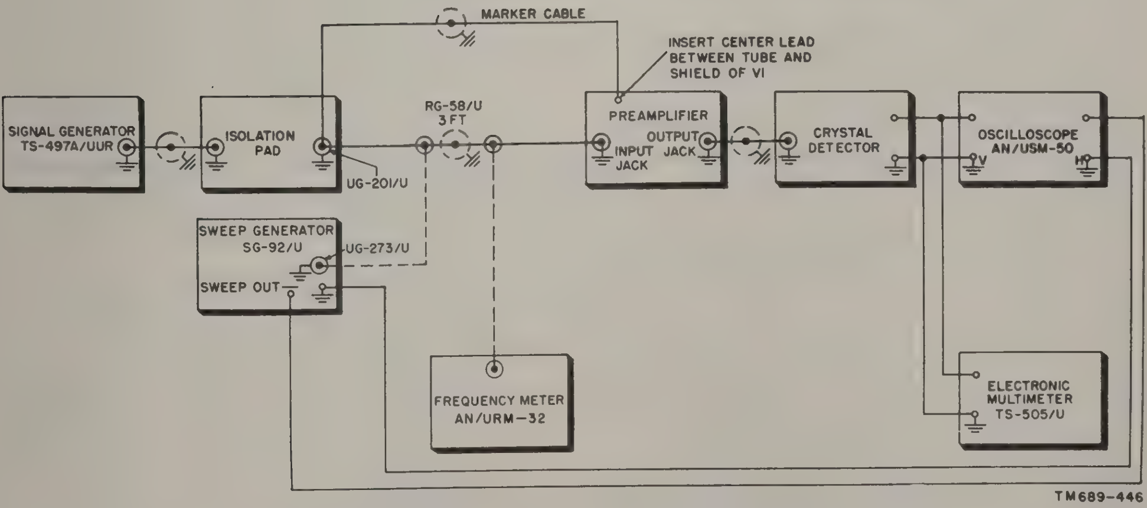
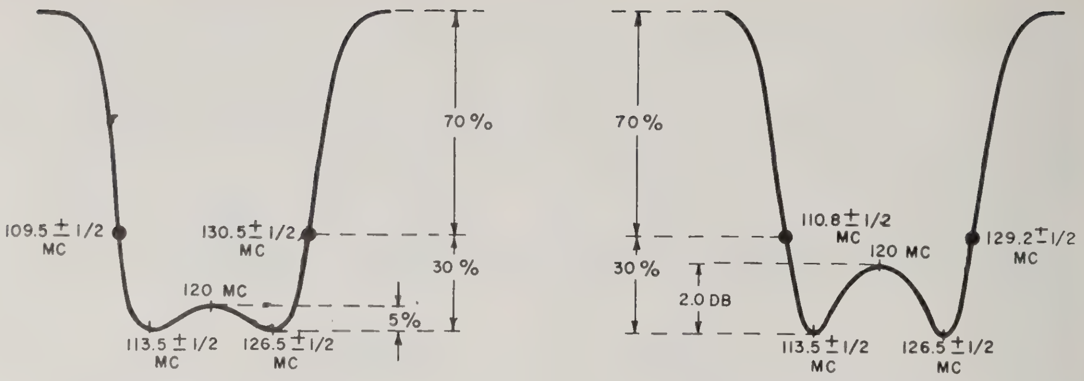

MARKER CABLE
INSERT CENTER LEAD
BETWEEN TUBE AND
SHIELD OF VI
SIGNAL GENERATOR
TS-497A/UUR
ISOLATION
PAD
RG-58/U
3 FT
PREAMPLIFIER
INPUT
JACK
OUTPUT
JACK
CRYSTAL
DETECTOR
OSCILLOSCOPE
AN/USM-50
V
H
UG-201/U
SWEEP GENERATOR
SG-92/U
UG-273/U
SWEEP OUT
FREQUENCY METER
AN/URM-32
ELECTRONIC
MULTIMETER
TS-505/U
TM689-446

Figure 374. Test setup for if. preamplifier alinement.



A. RESPONSE FROM 1ST AMPLIFIER GRID TO DETECTOR

B. RESPONSE WITH EQUIVALENT MIXER AHEAD OF PREAMPLIFIER

TM 689-447

Figure 375. If. preamplifier response waveform.

r. Adjust the output level of the sweep generator for a 0.5-volt reading on the vtvm.

s. Set the sweep voltage for maximum deviation. A response now should appear on the oscilloscope.

t. Couple the signal generator output through the marker injection cable to V1 as shown in figure 374. When using the marker signal, keep level as low as possible to prevent distortion of the response.

u. Tune L9 and L11 until a response similar to that shown in A, figure 375, is obtained. Use markers as a guide in alinement.

v. Remove the bottom cover of the preamplifier and remove the jumper and 51-ohm resistor connected in *b* above. Replace the bottom cover of the preamplifier.

w. Connect the equivalent mixer between the sweep generator and preamplifier as shown in figure 376.

x. With the sweep voltage deviation reduced to zero, set the sweep generator output level so that the vtvm reads 0.5 volt. Then reset the sweep voltage for maximum deviation.

y. Tune L1 and L4 until a response similar to that shown in B, figure 375, is obtained. Use markers as a guide in alinement. The 3-db, peak, and valley frequencies, as measured with the marker, should agree closely with those shown in figure 375.

237. 120-Mc If. Amplifier, Limiters, and Discriminator Alinement

The 120-mc if. amplifier (V7–V12), limiters (V13 and V14), and discriminator (V15) are alined as described below. It is assumed in this procedure that all circuit breakers are in the OFF position initially.

a. Preliminary If. Amplifier Alinement. The if. amplifier is alined initially as follows:

(1) Connect the signal generator through its isolation pad to the matching pad (50-ohm side) with the 3-foot coaxial cable (fig. 377). Ground the agc lead at terminal 8, TB4.

(2) Disconnect the if. amplifier input cable from the preamplifier and connect the input cable to the matching pad (91-ohm side).

(3) Connect the vtvm to terminal 7 of the fanning strip (1st limiter grid).

(4) Set the signal generator output at a minimum, and apply low-voltage power to the receiver rack as described in paragraph 80*a*. Allow a 10-minute warmup period.

(5) Set the signal generator frequency to 120 mc and increase the output level of the generator until a meter reading of 2.2-volts dc is obtained.

(6) Using the alinement tool, adjust L32

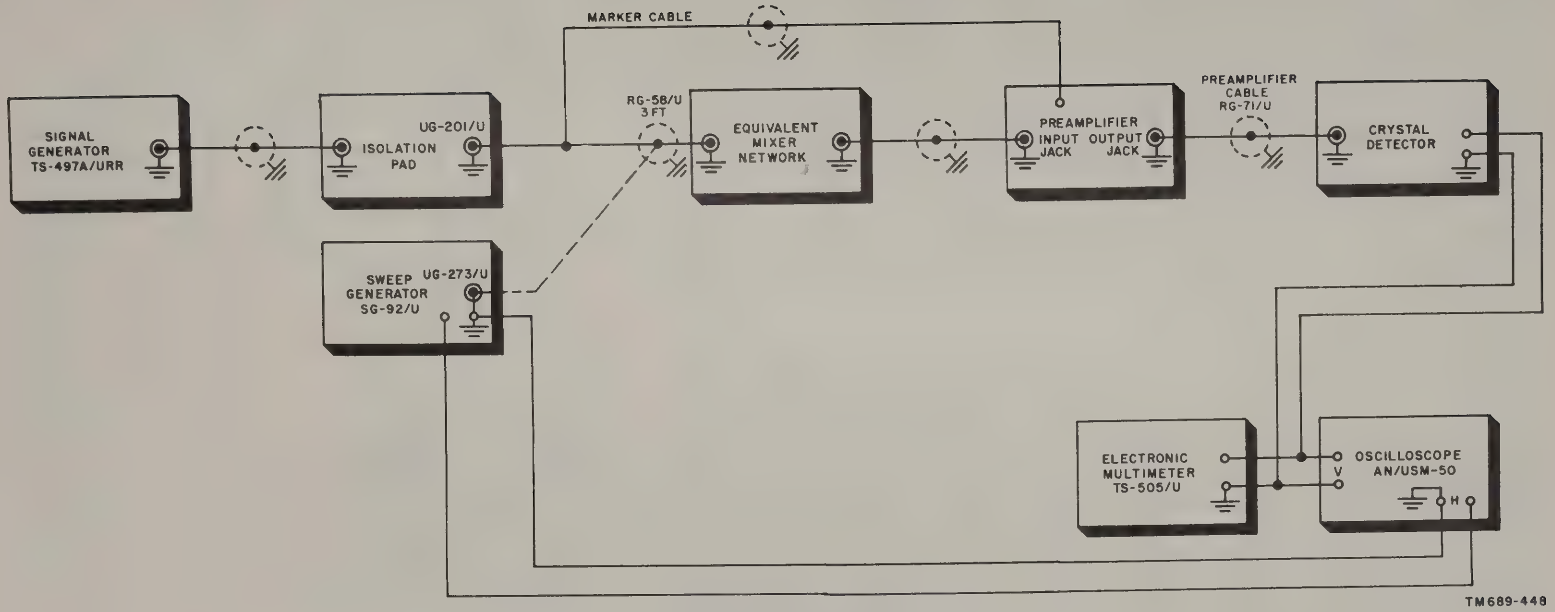

MARKER CABLE
SIGNAL GENERATOR TS-497A/URR
ISOLATION PAD
UG-201/U
RG-58/U 3 FT
EQUIVALENT MIXER NETWORK
PREAMPLIFIER INPUT JACK OUTPUT JACK
PREAMPLIFIER CABLE RG-71/U
CRYSTAL DETECTOR
SWEEP GENERATOR SG-92/U
UG-273/U
ELECTRONIC MULTIMETER TS-505/U
OSCILLOSCOPE AN/USM-50
V
H
TM689-448

Figure 376. Test setup for if. preamplifier input circuit alinement.

until the meter reads a maximum. While adjusting L32, reduce the generator level so that the meter reading stays at 2.2 volts.

(7) With the signal generator tuned to 110.5 mc, repeat the procedure in (6) above for L30.

(8) With the signal generator tuned to 130.5 mc, repeat the procedure in (6) above for L28.

(9) With the signal generator tuned to 110.5 mc, repeat the procedure in (6) above for L26.

(10) With the signal generator tuned to 120 mc, repeat the procedure in (6) above for L24.

(11) With the signal generator tuned to 130.5 mc, repeat the procedure in (6) above for L22.

b. Preliminary Limiter Alinement. The first and second limiters are alined initially as follows:

(1) Substitute the sweep generator for the signal generator and connect terminal 7 to oscilloscope (fig. 377) in parallel with the meter. Connect synchronizing cable between the oscilloscope and sweep generator.

(2) With the sweep voltage at zero, set the generator center frequency to 120 mc.

(3) Adjust the output attenuator on the sweep generator for a 2.2-volt, dc reading on the meter.

(4) Set the sweep voltage on the generator to maximum deviation. A response now should appear on the oscilloscope.

(5) Reduce the sweep voltage so that only top 30 percent of the response is visible on the oscilloscope as illustrated in A, figure 370.

(6) Adjust the center frequency of the sweep generator so that the ends of the response terminate on the same horizontal line on the oscilloscope screen (A, fig. 370).

(7) Remove the top cover of the amplifier chassis.

(8) Connect the oscilloscope and vtvm to test point E2, second limiter grid (fig. 377).

(9) Tune limiter coils L34 and L35 for maximum reading on the vtvm.

(10) Adjust L35 so that peaks of the response waveform on the oscilloscope are equal.

(11) Adjust L34 so that the ends of the response waveform terminate on the same horizontal line of the oscilloscope (C, fig. 370).

(12) Repeat the procedures in (10) and

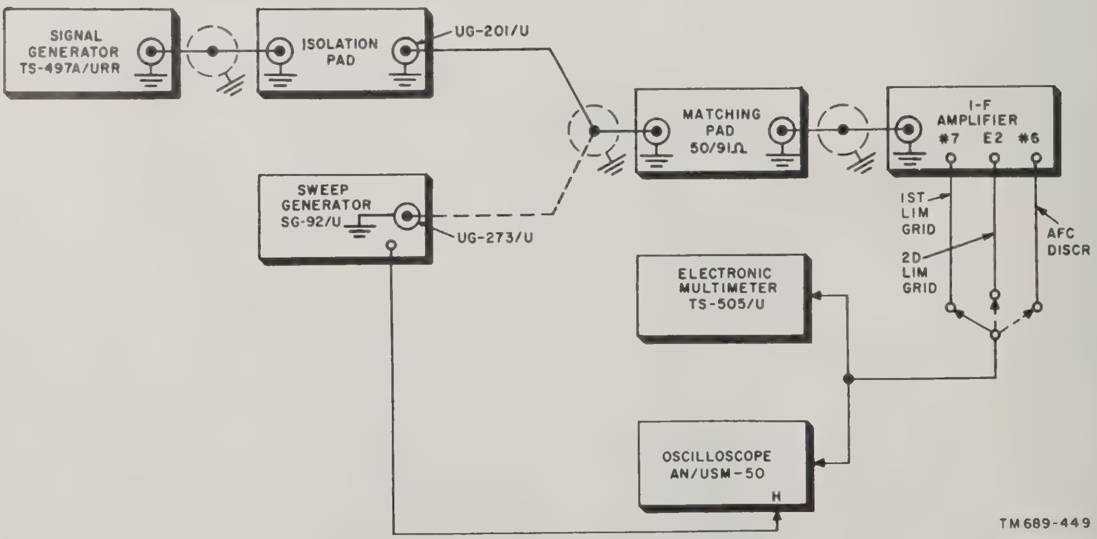

SIGNAL GENERATOR TS-497A/URR
ISOLATION PAD
UG-201/U
MATCHING PAD 50/91Ω
I-F AMPLIFIER
#7
E2
#6
SWEEP GENERATOR SG-92/U
UG-273/U
1ST LIM GRID
2D LIM GRID
AFC DISCR
ELECTRONIC MULTIMETER TS-505/U
OSCILLOSCOPE AN/USM-50
H
TM689-449

Figure 377. If. amplifier alinement test setup.

(11) above. Because of interaction between L35 and L34, it may be necessary to repeat these procedures several times before a response like that shown in C, figure 370, is obtained.

c. Preliminary Discriminator Alinement. The discriminator is alined initially as follows:

(1) Substitute the signal generator for sweep generator (fig. 378).

(2) Connect the vtvm to terminal 7 of the fanning strip, tune the signal generator to 120 mc, and set its output level for a 2.2-volt reading on the vtvm.

(3) Connect the vtvm to terminal 6, the discriminator output, and tune L38 for maximum voltage on the vtvm.

(4) Connect the vtvm to terminal 7 of the fanning strip, tune the signal generator to 108 mc, and set its output level for a 2.2-volt reading on the meter.

(5) Connect the vtvm to terminal 6 of the fanning strip and tune L39 for maximum negative voltage on the meter.

(6) Tune the generator to 141 mc and set its output level for maximum output.

(7) Tune L40 for a maximum positive voltage on the meter.

(8) Repeat the procedures outlined in (4) through (7) above until there is no reaction between the tuning of L39 and L40.

(9) Zero the vtvm on its 2-volt range. Connect it to terminal 6.

(10) Slowly tune the generator about 120 mc until the vtvm reads zero.

(11) Disconnect the signal generator from the if. amplifier input cable and connect it to the frequency meter as indicated in figure 378.

(12) With the frequency meter, determine the exact frequency of the signal generator set in (10) above.

(13) Calibrate the signal generator dial at frequencies of 115, 120, and 125 mc and record the dial readings. These calibration points will be used in setting the generator frequency for the remainder of the alinement.

(14) Reconnect the signal generator to if. amplifier and set the generator to 120 mc.

(15) Set the signal generator level for 2.2 volts at terminal 7.

(16) If the discriminator *zero* frequency determined in (10) above was below 120 mc, rotate the tuning screws on L39 and L40 equal increments in a counterclockwise direction until the vtvm, connected to terminal 6, reads exactly zero. Total rotation should not be more than 1½ turns, otherwise

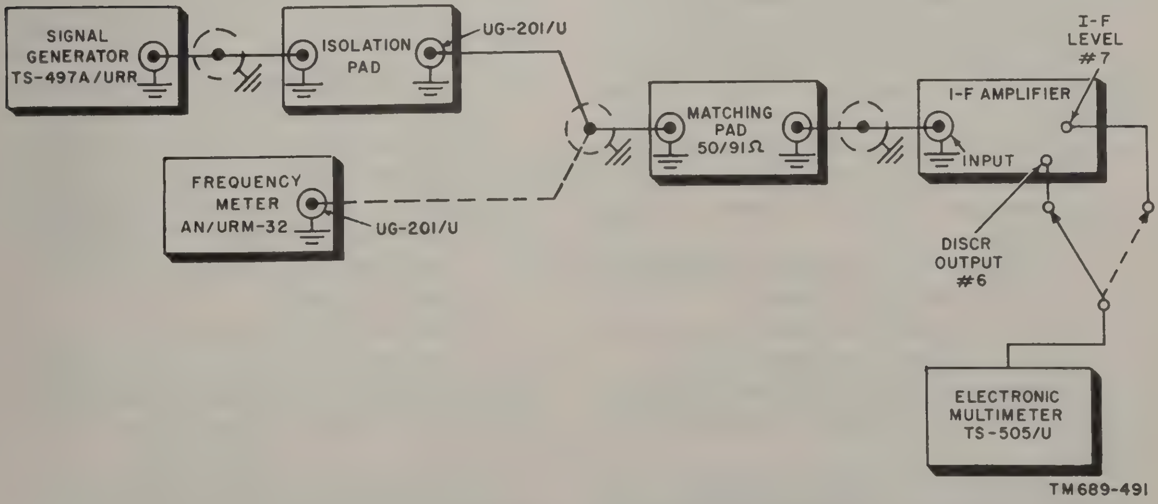


Figure 378. Discriminator alinement and sensitivity test setup.

the discriminator alinement should be repeated.

(17) If discriminator frequency in (10) above was above 120 mc, rotate the tuning screws on L39 and L40 equal increments in a clockwise direction until the vtvm, connected to terminal 6, reads exactly zero.

(18) Set the signal generator frequency to 115 mc and adjust its level for 2.2 volts at terminal 7.

(19) Measure the negative voltage at terminal 6.

(20) Set the signal generator frequency to 125 mc and output level to 2.2 volts at terminal 7.

(21) Measure the positive voltage at terminal 6.

(22) Compare the discriminator voltages obtained in (19) and (21) above.

(23) Set the signal generator to a frequency corresponding to the lower of the two values obtained in (19) and (21) above and adjust the generator level for a 2.2-volt reading at terminal 7.

(24) Set the meter to the proper range, zero meter, and connect it to terminal 6.

(25) Adjust L38 so that the lower discriminator voltage is equal to the higher voltage.

(26) If necessary, repeat the procedures in (18) through (25) above until outputs from the discriminator are equal.

d. Final Alinement of Limiters. The final alinement of the limiters is performed as follows:

(1) Connect the sweep generator to the matching pad and the vtvm and oscilloscope to terminal 7 as shown in figure 377.

(2) Repeat the procedures outlined in *b*(1) through (6) above.

(3) Repeat the procedures outlined in *b*(8) through (12) above.

e. Final If. Amplifier Alinement. The final alinement of the if. amplifier is performed as follows:

(1) Connect the signal generator to the matching pad and the vtvm to terminal 7.

(2) Repeat the procedures in *a*(5) through (11) above.

f. Final Discriminator Alinement. The final discriminator alinement is performed as follows:

(1) Connect the signal generator to the matching pad as shown in figure 377.

(2) Measure the discriminator output voltages at 115 and 125 mc by repeating the procedures in *c*(18) through (21) above, making sure to zero set the vtvm.

(3) If voltages are unequal, repeat the procedures in *c*(23) through (26) above.

(4) Measure the discriminator zero frequency by repeating the procedures in *c*(9) through (12) above.

(5) If the discriminator zero frequency is not within 100 kc of 120 mc, repeat the preliminary discriminator alinement procedure given in *c* above.

(6) Remove ground from agc lead at terminal 8, TB4.

238. Afc If. Amplifier and Discriminator Alinement

The afc if. amplifier (V25-V27) and discriminator (CR4 and CR5) are alined as follows:

a. If. Amplifier Alinement.

(1) Check the tuning of the crystal multiplier.

(2) Turn the POWER and HV PL switches OFF and remove the cover from this subassembly. Connect the test equipment to afc subassembly as shown in figure 379.

(3) Connect the vtvm to terminal 5 of the fanning strip.

(4) Apply low-voltage power to the receiver as described in paragraph 80*a* and allow the receiver to stabilize at least 10 minutes.

(5) Set the signal generator to 36 mc, unmodulated.

(6) Vary the output of the signal generator so that the vtvm reads —0.5-volt dc.

(7) Adjust coil L52 for a maximum vtvm reading, and simultaneously vary the signal generator output so that the

maximum vtvm reading is —0.5 volt.

(8) Set the signal generator to 33 mc.

(9) Adjust coil L54 for a maximum vtvm reading, and simultaneously vary the signal generator output so that the maximum vtvm reading is —0.5 volt.

(10) Repeat the procedures in (5) and (7) above.

(11) Turn off the power and replace the cover.

b. Discriminator Alinement.

(1) Perform the procedures in *a*(1) and (2) above.

(2) Place the AFC OFF–ON switch in the OFF position and connect the vtvm to terminal 5 of the fanning strip.

(5) Turn on the frequency meter and allow it to stabilize.

(6) Turn the slug in coil L57 completely counterclockwise.

(7) Connect a jumper between terminal 7 of the fanning strip and chassis.

(8) Connect the vtvm to terminal 6. Use +40-volt scale.

(9) Set the frequency meter to 34.5 mc.

(10) Vary the frequency of the signal generator until a beat is obtained on the frequency meter.

(11) Turn off the frequency meter.

(12) Tune coil L56 for maximum vtvm reading.

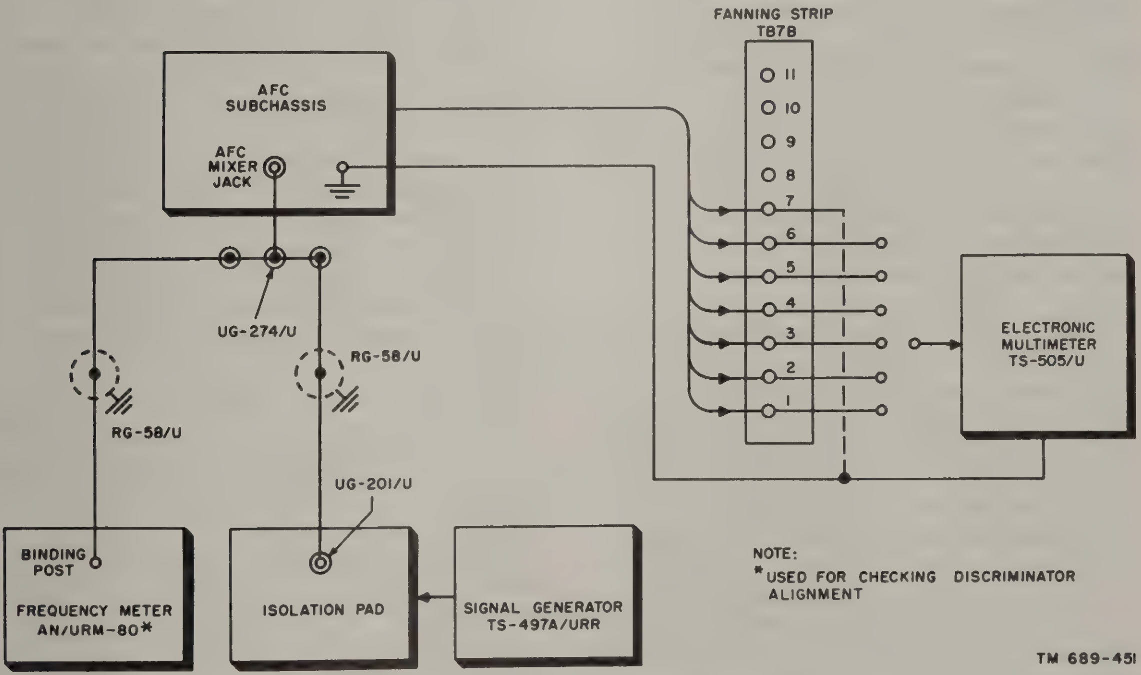

FANNING STRIP
TB7B
11
10
9
8
7
6
5
4
3
2
1
AFC SUBCHASSIS
AFC MIXER JACK
UG-274/U
RG-58/U
RG-58/U
UG-201/U
ELECTRONIC MULTIMETER TS-505/U
BINDING POST
FREQUENCY METER AN/URM-80*
ISOLATION PAD
SIGNAL GENERATOR TS-497A/URR
NOTE:
*USED FOR CHECKING DISCRIMINATOR ALIGNMENT
TM 689-451

Figure 379. Test setup for afc if. amplifier and discriminator alinement.

(3) Apply low-voltage power to the receiver as described in paragraph 80*a* and allow the receiver to stabilize at least 10 minutes.

(4) Set the signal generator to 34.5 mc and adjust its output for a 0.5-volt reading on the vtvm.

(13) Tune coil L57 for a zero vtvm reading.

(14) Turn off the power and remove the jumper.

239. Adjustment of Beam Current

The klystron beam current should be adjusted as follows:

a. Place the POWER switch in the OFF position.

b. Connect the multimeter between terminal 4 of TB6A and terminal 4 of TB6B so that current between these points can be measured.

c. Connect the vtvm between terminal 4 of TB6A and ground.

d. Place the POWER switch in the ON position.

e. Adjust the BEAM CURRENT control for a 15-ma reading on the meter. If a 15-ma reading cannot be obtained, set the BEAM CURRENT control fully clockwise.

f. If a reading other than —300-volts dc is obtained on the vtvm, adjust the BEAM V ADJ control on the receiver power supply for a —300-volt reading.

g. Repeat the procedures in *e* and *f* above until both conditions are met.

240. Alinement of Preselector and If. Coupling Coil

The preselector and if. coupling coil, L19, are alined as follows:

a. Connect the test equipment to the radio receiver as shown in figure 380.

b. With the signal generator output level at a minimum, apply power to the radio receiver. Allow a 10-minute warmup period.

c. Set the IF. LEVEL potentiometer to its maximum clockwise position.

d. Place the assigned channel crystal into the crystal socket and aline the crystal multiplier and local oscillator for the assigned channel. Set the preselector to the approximate setting by using the channel scale marking.

e. Adjust the signal generator frequency to the channel carrier frequency.

f. Set the right hand meter switch (S3) to the IF. DISCR FREQ HIGH position and the left hand meter switch to the IF. LEVEL position.

g. Watch the right hand meter B and vary the signal generator frequency so that the meter indication goes through the zero reading; then readjust the signal generator frequency back to a zero reading. The frequency at which this zero reading is obtained is called the discriminator crossover frequency. Maintain this frequency for the remainder of the alinement.

h. Detune the preselector primary by raising its shorting plunger.

i. Adjust the signal generator output for an IF. LEVEL meter reading of 60.

j. Vary the INCR FREQ knob on the preselector for maximum IF. LEVEL meter reading. If the reading goes over 70, readjust the signal generator for a reading of 70.

k. Lower the primary shorting plunger to its normal position and detune the preselector secondary by raising its shorting plunger.

l. Adjust the vernier tuning screw for maximum IF. LEVEL meter reading. If the meter reading rises above 70, reduce the generator output level.

m. Lower the secondary shorting plunger and reduce the generator output until an IF. LEVEL meter reading of 60 is obtained.

n. With the alinement tool, adjust the preamplifier output circuit coil, L19, for maximum IF. LEVEL meter reading. The coil adjustment screw is located adjacent to the preamplifier output jack.

o. As a check on the alinement, slowly tune the signal generator 10 mc above and below the crossover frequency. Note the IF. DISCR FREQ HIGH and IF. DISCR FREQ LOW and IF. LEVEL meter readings.

p. Note and record the maximum IF. LEVEL meter readings and corresponding IF. DISCR FREQ HIGH and IF. DISCR FREQ LOW meter readings. The frequencies at which these maximums occur can be determined from the

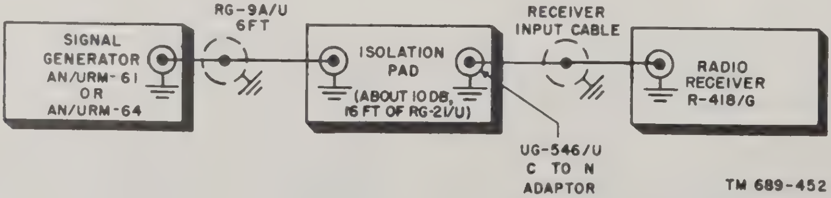


Figure 380. Test setup for preselector and if. coupling coil alinement.

IF. DISCR FREQ HIGH or IF. DISCR FREQ LOW meter reading. The sensitivity of this meter is 12 units per mc.

q. Note and record the minimum IF. LEVEL meter reading and corresponding frequency as determined from IF. DISCR FREQ HIGH or IF. DISCR FREQ LOW meter reading.

r. If receiver is alined correctly, the receiver response should have two maximums spaced at 5.5 to 6 mc on either side of the crossover frequency, with the minimum at or close to the crossover frequency. The ratio of maximum to minimum IF. LEVEL meter readings should not exceed 1.25.

Section IV. FINAL TESTING

241. General

a. This section is intended as a guide to be used in determining the quality of a repaired Radio Set AN/TRC–29. The minimum test requirements outlined in paragraphs 243 through 250 may be performed by maintenance personnel with adequate test equipment and necessary skills. Repaired equipment meeting these requirements will furnish uniformly satisfactory operation.

b. When a major repair has been performed on a component, the component should be checked in accordance with the procedures outlined in this section. In the case of the radio transmitter and the radio receiver, where a relatively long period of time is required to perform all of the tests, it is possible to limit final testing to checking those performance characteristics that may have been affected by the repaired circuit. However, if time permits, all of the tests given for these components should be made.

242. Test Equipment Required for Final Testing

a. Order-Wire Transmitter. The following test equipment is required for checking the operation of the order-wire transmitter:

(1) *Vtvm.* A vtvm, such as Electronic Multimeter TS–505/U, is required to have a dc voltage range of 0 to ±2 volts and 0 to ±200 volts. The input impedance should be 1 megohm, or higher.

(2) *Oscilloscope.* An oscilloscope, such as Oscilloscope AN/USM–50, is required to have a frequency response to at least 6 mc and a sensitivity of at least 35 millivolts rms per inch.

(3) *Heterodyne frequency meter.* A heterodyne frequency meter, such as Frequency Meter AN/URM–79, is required to measure a 6.000-mc signal.

b. Radio Transmitter. The following test equipment is required for checking the operation of the radio transmitter:

(1) *Oscilloscope.* This oscilloscope is the same as that listed in *a*(2) above.

(2) *Vtvm.* This vtvm is the same as that listed in *a*(1) above. Two vtvm are required.

(3) *Wattmeter.* A wattmeter, such as Wattmeter ME–69/U, is required to measure up to 10 watts of power in the frequency range of 1,700 to 2,400 mc.

(4) *Multimeter.* A multimeter, such as Multimeter TS–352/U, is required to measure voltage to at least —2,500 volts.

(5) *Audio oscillator.* An audio oscillator, such as Audio Oscillator TS–382/U, is required to have a frequency range 10 cps to 30 kc, and an output level variable from 0 to 2.5 volts.

(6) *Video signal generator.* A video signal generator, such as Signal Generator AN/URM–25D, is required to have a frequency range from 20 kc to 6.0 mc and output voltage continuously variable from 0 to 50 millivolts.

(7) *Video signal generator.* A video signal generator, such as Hewlett Packard Model 650A, may be used instead of either or both instruments listed in (5) and (6) above.

c. Power Supply PP–764/G. The following test equipment is required for checking the operation of the high-voltage power supply:

(1) *Ac vtvm.* An ac vtvm, such as Voltmeter ME–30A/U, is required to measure ripple voltages from 1 millivolt to 1 volt.

(2) *Multimeter.* Same as the multimeter listed in *b*(4) above.

(3) *Oscilloscope.* Same as the oscilloscope listed in *a*(2) above.

d. Order-wire Receiver. The following test equipment is required for checking and adjusting the order-wire receiver.

(1) *Vtvm.* This vtvm is the same as the vtvm listed in *a*(1) above.

(2) *Oscilloscope.* This oscilloscope is the same as the oscilloscope listed in *a*(2) above.

(3) *Heterodyne frequency meter.* This meter is the same as the heterodyne frequency meter listed in *a*(3) above.

e. Radio Receiver. The following test equipment is required for checking and adjusting the radio receiver:

(1) *Multimeter.* A multimeter, such as Multimeter TS–352/U, is required with a current range of at least 0 to 30 ma with a 3 percent accuracy.

(2) *Vtvm.* A vtvm, such as Electronic Multimeter TS–505/U, is required to measure ±1,000 volts dc, with an accuracy of 4 percent.

(3) *Heterodyne frequency meter.* A heterodyne frequency meter, such as Frequency Meter AN/URM–81, is required with the following characteristics: frequency range (by harmonics) of 1,835 to 2,505 mc; accuracy of 0.04 percent, and incremental accuracy of 0.001 percent.

(4) *Oscilloscope.* This oscilloscope is the same as the oscilloscope listed in *a*(2) above.

(5) *Rf signal generator.* An rf signal generator is required to provide at least a 200-millivolt output in the frequency range of 1,700 to 2,400 mc. Signal Generator AN/URM–64 can be used to cover the range of 1,700 to 2,400 mc and Signal Generator AN/URM–61 can be used to cover the range of 1,820 to 2,400 mc.

(6) *If. signal generator.* An if. signal generator, such as Signal Generator TS–497A/URR, is required with at least the following characteristics: frequency range of 100 to 145 mc; frequency calibration which is accurate within 0.5 percent; output impedance of 50 ohms; and a variable output level between 0 and 100 millivolts.

(7) *If. marker injection cable.* A special marker injection cable must be made up as indicated in figure 363.

(8) *Coaxial adapters.* An Adapter Connector UG–914/U and an Adapter UG–349A/U are required.

(9) *Rf isolating pad.* An rf isolating pad that consists of about 16 feet of RG–21A/U is required to provide 10-db attenuation in the range of 1,700 to 2,400 mc.

f. Power Supply PP–690/G. The following test equipment is required for checking the operation of the receiver power supply:

(1) *Multimeter.* A multimeter, such as Multimeter TS–352/U, is required with at least the following characteristics: voltage range of 400 volts; 20,000 ohms per volt; and accuracy of 3 percent.

(2) *Ac vtvm.* This vtvm is the same as the ac vtvm listed in *c*(1) above.

(3) *Oscilloscope.* This oscilloscope is the same as the oscilloscope listed in *a*(2) above.

g. Power Supply PP–689/G. The following test equipment is required for checking the operation of the transmitter low-voltage power supply:

(1) *Ac vtvm.* This vtvm is the same as the ac vtvm listed in *c*(1) above.

(2) *Multimeter.* This multimeter is the same as the multimeter listed in *b*(4) above.

(3) *Oscilloscope.* This oscilloscope is the same as the oscilloscope listed in *a*(2) above.

h. Radio Set AN/TRC–29, Overall. The following test equipment is required for the overall check and adjustment of the radio set:

(1) *Audio and video signal generators.* These generators are the same as the audio and video signal generators listed in *b*(5) through (7) above.

(2) *Vtvm.* Same as vtvm listed in *a*(1) above. Two of these vtvms are required.

(3) *Oscilloscope.* This oscilloscope is the

same as the oscilloscope listed in *a*(2) above.

243. Final Test of Order-Wire Transmitter

The order-wire transmitter is tested as described below.

a. Power Supply and Oscillator. The power supply and oscillator are checked as follows:

(1) Measure the resistance across C35 (B+ to ground). It should be greater than 100K.

(2) Adjust the INCREASE OUTPUT control on the autotransformer for a LINE VOLTS meter reading (on the radio transmitter) as close as possible to 115 volts.

(3) Apply low-voltage power to the transmitter rack as described in paragraph 76*a*. All filaments in the order-wire transmitter should light.

(4) Place the PLATE circuit breaker in the ON position. Tube V11 should glow.

(5) Measure the voltage across C33. It should be between —100 and —110 volts dc.

(6) Measure the voltage across C35. It should be +140 volts ±5 volts.

(7) Measure the voltage across R46. It should be between 15 and 20 volts dc.

(8) Check the oscillator frequency with Frequency Meter AN/URM–79 by placing its pickup loop near the FREQ ADJ coil. It should be 6.000 mc.

(9) Place the ORDER WIRE TEST SWITCH in AFC OFF position. Oscillator frequency should not change more than ±1 kc.

b. Carrier Output Level Check. Check the carrier output level as follows:

(1) Disconnect the cable from the ORDER WIRE CARR OUTPUT jack. Connect a 5-foot RG–58C/U to this jack. Terminate the other end of the coaxial cable in a 500-ohm resistor. Place the oscilloscope across this resistor.

(2) Calibrate the level obtained on the oscilloscope. It should be greater than 250 millivolts with the ORDER WIRE CARR LEVEL control fully clockwise.

(3) Turn the ORDER WIRE CARR LEVEL control fully counterclockwise. The output should be greater than 10 millivolts.

(4) Depress the RING button on the order-wire receiver. The output should drop below 2 millivolts for a period of about 1 second (if the RING button is kept depressed) and then return to the original level, although the RING button still is depressed.

244. Final Test of Radio Transmitter

The radio transmitter is tested as described below.

a. Electronic Voltage Regulator, Modulator, and Vtvm. Check the operation of the electronic voltage regulator, modulator, and vtvm as follows:

(1) With the POWER switch in the OFF position, connect the multimeter between terminal 8 of TB9 and ground. Set the meter to the negative voltage scale with the voltage range in excess of —2,500 volts.

(2) Apply the klystron voltage to the radio transmitter as described in paragraph 77.

(3) A meter reading of —1,295 volts ±10 percent should be obtained.

(4) Turn off the power and disconnect the meter.

(5) Apply low-voltage power to the radio transmitter as described in paragraph 76*a* and place the VTVM SEL SW in the GND position.

(6) Place the PEAK VTVM meter switch in POS PEAK position and adjust the VTVM ZERO BALANCE POS control for a zero reading on PEAK VTVM.

(7) Place the PEAK VTVM meter switch in the NEG PEAK position and adjust the VTVM ZERO BALANCE NEG control for a zero reading on PEAK VTVM.

(8) Turn the POWER switch OFF. Remove the protective cover on the modulator. Connect the vtvm across the modulator output, that is, between the junction of R52 and C25 and ground (fig. 367).

(9) Connect Audio Oscillator TS–382/U through a 560-ohm resistor to the

VIDEO INPUT receptacle at the back of the radio transmitter.

(10) Connect another vtvm across the output terminals of the audio oscillator.

(11) Adjust the audio oscillator frequency to 500 cps and its output level for a 1.2-volt reading on the vtvm across its terminals.

(12) Turn the POWER switch ON. Place the MOD INPUT SEL SW in the VID position and INPUT VIDEO LEVEL control fully clockwise. The modulator output should be 44 volts rms ±10 percent.

(13) Connect a 50-ohm terminating resistor across the MON REC OUTPUT jack. Place a vtvm across this resistor. A meter reading of approximately 0.33 volt should be obtained when the transmitter is modulated 100 percent.

(14) Adjust the signal generator level so that the modulator output voltage is 35.4 volts rms.

(15) Place the VTVM SEL SW in the MOD OUT position. The PEAK VTVM meter reading should be exactly 50 on the black scale. Switch from the POS PEAK to the NEG PEAK or vice versa. The meter reading should not change.

(16) Place the MOD INPUT SEL SW in the GND position. The modulator output meter reading should be less than 100 millivolts.

b. Frequency Response of Modulator, Vtvm, and Monitor Receiver. Check the frequency response of the modulator, vtvm, and monitor receiver as follows:

(1) Connect the audio oscillator to the VIDEO INPUT jack through a 560-ohm resistor as shown in figure 367.

(2) Connect a vtvm across the output terminals of the audio oscillator and another one at the modulator output.

(3) Set the audio oscillator to 500 cps and the output level for a PEAK VTVM meter reading of 50 percent with VTVM SEL SW in MON OUT position. Note the reading on the multimeter.

(4) Keep the modulator input voltage at the reading noted in (3) above and vary the frequency of the signal generator as described in paragraph 233*d*(4) through (7). At each frequency, read, plot, and normalize the readings of the following meters:

- (*a*) Modulator output vtvm.
- (*b*) PEAK VTVM in the NEG PEAK position with VTVM SEL SW in the MOD OUT position.
- (*c*) PEAK VTVM in the POS PEAK position with VTVM SEL SW in the MOD OUT position.
- (*d*) PEAK VTVM in the NEG PEAK position with VTVM SEL SW in the MON OUT position.
- (*e*) PEAK VTVM in the POS PEAK position with VTVM SEL SW in the MON OUT position.
- (*f*) Reading obtained across MON REC OUTPUT terminating resistor.

(5) The response curve obtained in (4)(*a*) above should compare with the curve given in figure 368 (115-volt line voltage).

(6) The response curves obtained in (4)(*b*) through (*e*) above should compare with curves given in figure 381.

(7) The response curve obtained in (4)(*f*) above should compare with the curve given in figure 382.

c. Power Output Measurement. Check the power output of the transmitter as follows:

(1) Turn the power off. Disconnect the 20-db cable from the RF OUT jack and connect Wattmeter ME–69/U to this jack. Turn the power on again.

(2) Place MOD SEL SW in the GND position.

(3) Make sure that the LINE VOLTS meter reading is as close as possible to 115 volts.

(4) Make sure that the PA CATH CUR. reading on the left hand meter is 100.

(5) Determine the power output on the ME–69/U. It should compare with the value indicated in figure 383.

Note. The tests indicated in *d* and *e* below should be performed on units to be used as depot stock.

d. Checking Operation at Other Line Voltages. Repeat the procedure given in *a* through *c* above for a line voltage of 103.5 and 126.5.

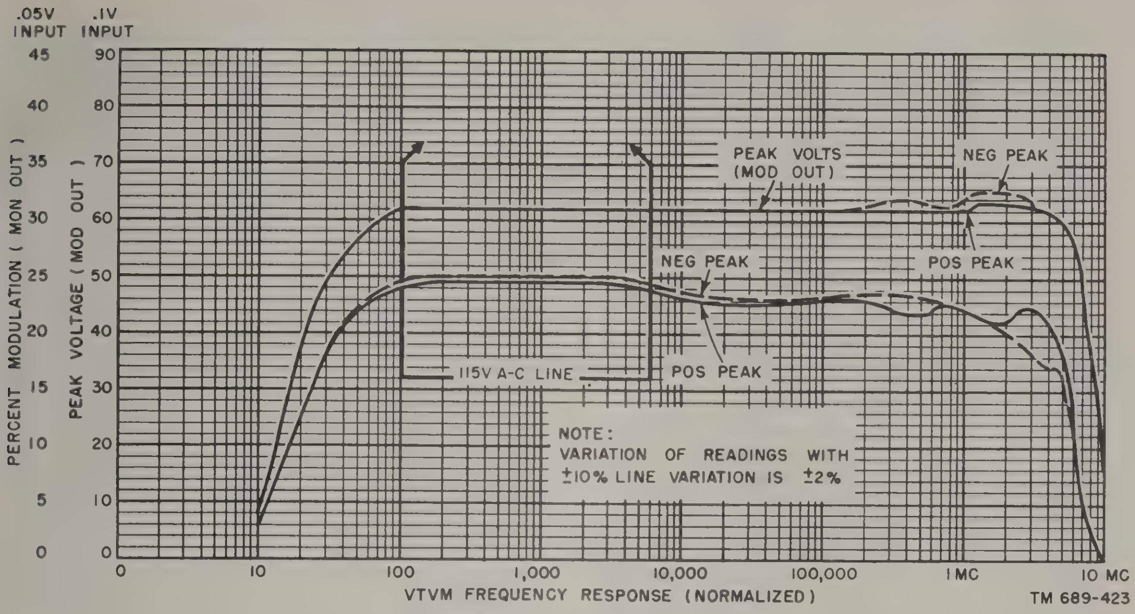


Figure 381. Vtvm response curves.

e. Checking Operation at Other Frequencies. The procedure given in *c* above should be repeated for channels 1, 15, and 27. When changing the frequency, be sure that the proper klystron and crystal are used (pars. 33 and 39*g*).

245. Final Test and Adjustment of Power Supply PP–764/G

The high-voltage power supply is checked and adjusted as follows:

a. Check the terminal board resistances to ground (fig. 307).

b. Place the VARIABLE AUTOTRANSFORMER switch to 0 and the PA PLATE VOLTAGE ADJUST–KLYSTRON BEAM VOLTAGE TEST ADJUST switch to the PA PLATE VOLTAGE ADJUST position.

c. Place all circuit breakers in the power supply in the ON position, including INPUT POWER BREAKER circuit breakers (CB1 and CB2) on the back of the unit. Place the POWER circuit breaker in the radio transmitter in the ON position and FIL and PLATE circuit break-

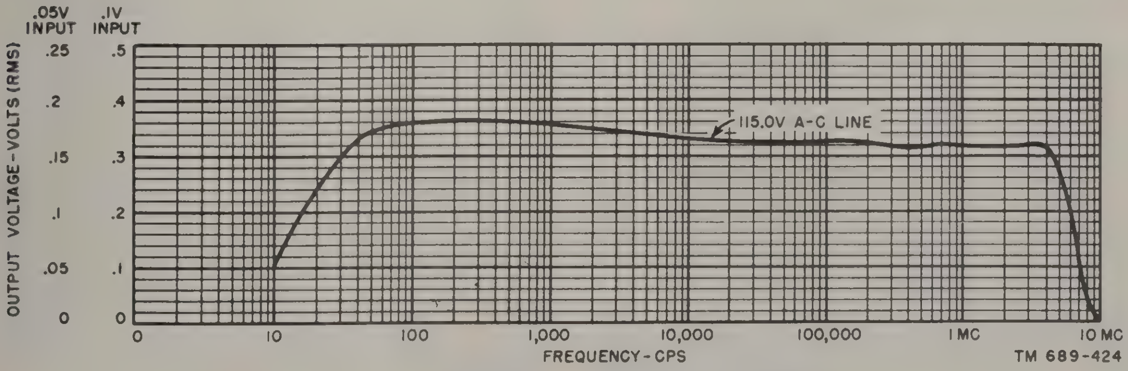


Figure 382. Monitor receiver output frequency response.

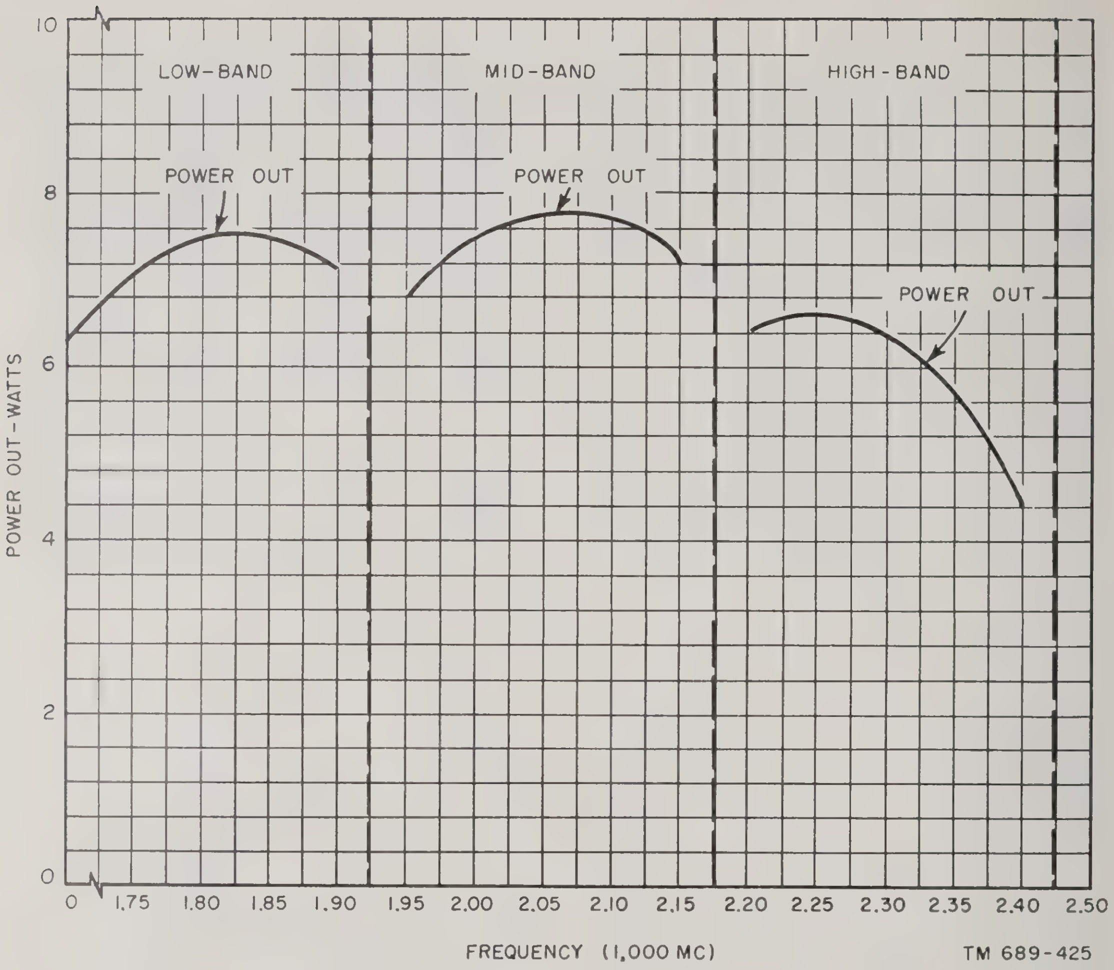


Figure 383. Power output versus frequency curve.

ers in the order-wire transmitter in the ON position. Allow the unit to warm up.

d. The LINE VOLTS meter reading should be as close as possible to 115 volts.

e. Place the INPUT POWER BREAKER circuit breakers in the OFF position and connect Multimeter TS–352/U between terminal 18 of TB2 and ground. Use a 5,000-volt scale initially. Connect the vtvm and scope through a 4-μf, 2,000-volt capacitor in parallel with the multimeter. Place the INPUT POWER BREAKER circuit breakers in the ON position.

f. Adjust the BEAM V ADJ control for a meter reading of —1,000 volts on the 5,000-volt scale. Turn the INPUT POWER BREAKER circuit breakers to OFF, set the meter on a 1,000-volt scale. Turn the INPUT POWER BREAKER circuit breakers to ON. Readjust the BEAM V ADJ control for a meter reading of —1,000 volts.

g. Note and record ripple voltage on the ac vtvm and oscilloscope. It should not exceed 25 millivolts.

h. Vary the line voltage to 103.5 volts. The dc output voltage should not drop below 995 volts and the ripple voltage should not exceed 50 millivolts.

i. Vary the line voltage to 126.5 volts. The dc output voltage should not exceed 1,005 volts, and the ripple voltage should not exceed 50 millivolts.

j. Place the INPUT POWER BREAKER circuit breakers in the OFF position. Connect the multimeter vtvm and the oscilloscope to terminal 4, TB2. Place the circuit breakers in the ON position. Adjust the line voltage to 115 volts.

k. Adjust the VARIABLE AUTOTRANSFORMER for a reading of +800 volts on the multimeter. Note the ripple voltage. It should not exceed 10 volts.

l. Vary the line voltage to 103.5 volts. The dc output voltage should not drop below 700 volts and the ripple voltage should not exceed 12 volts.

m. Vary the line voltage to 126.5 volts. The dc voltage should not exceed 950 volts, and the ripple voltage should not exceed 12 volts.

n. Place the INPUT POWER BREAKER circuit breakers in the OFF position. Place the multimeter, vtvm and oscilloscope between terminal 15 on TB3 and ground. Place the circuit breakers in the ON position.

o. With the line voltage at 115 volts, the dc output voltage should be —2,350 volts ±135 volts, and the ripple voltage should not exceed 0.8 volts.

p. With the line voltage at 103.5 volts, the dc output voltage should be not less than —2,200 volts and the ripple voltage should not exceed 1 volt.

q. With the line voltage at 126.5 volts, the dc output voltage should not exceed —2,500 volts and the ripple voltage should not exceed 1 volt.

r. Place the VARIABLE AUTOTRANSFORMER control to zero and the PA PLATE VOLTAGE ADJUST-KLYSTRON BEAM VOLTAGE TEST ADJUST to the KLYSTRON BEAM VOLTAGE TEST ADJUST position.

s. With the power turned off, place the multimeter between terminal 18, TB2, and ground. Turn on the power again.

t. Turn the VARIABLE AUTOTRANSFORMER control to the point marked KLYSTRON TEST. The multimeter should read about —500 volts.

246. Final Test of Order-Wire Receiver

The order-wire receiver is tested as described below.

a. Power Supply Check. The power supply is checked as follows:

(1) Measure the resistance between C26B and ground. It should be greater than 10K.

(2) Place the FIL circuit breaker in the ON position. All filaments should go on. (It is assumed that power has been applied to the receiver, and the receiver power supply circuit breakers are on.)

(3) Turn on the PLATE circuit breaker. Tube V13 should glow. Allow a 10-minute warmup period.

(4) Check the voltage with the dc vtvm between pin H on the DIVERSITY INTERCONN jack and ground. It should be between —100 and —110 volts dc. (LINE VOLTS should be as close as possible to 115 volts.)

(5) Measure the voltage across C26B with the vtvm. It should be +140 volts ±5 volts.

(6) Measure the dc voltage across R66. It should be between 9 and 11 volts.

b. Checking Carrier and Audio Circuits. The carrier and audio circuits are checked as follows:

(1) Disconnect all connecting cables from the back of order-wire receiver.

(2) Connect the cable from the LOW PASS FILTER INPUT to OW CARR FILTER OUTPUT.

(3) Connect the output of an order-wire transmitter obtained at the ORDER WIRE CARR OUTPUT receptacle to the VIDEO INPUT FROM REC jack of the order-wire receiver being tested.

(4) Using the frequency meter, adjust the output frequency of the order-wire transmitter to exactly 6.000 mc (unmodulated).

(5) Using an oscilloscope to measure the output level of the order-wire transmitter, vary the ORDER WIRE CARR LEVEL control for an output of 50 millivolts rms.

(6) Place the ORDER WIRE TEST SWITCH on the order-wire transmitter to the THRU TONE position. Adjust the AUDIO LEVEL THRU CHANNEL for an AUDIO meter reading of 100.

(7) Place the ac vtvm at pin E of REPEATER INTERCONN jack. A me-

ter reading of 0.776 volt rms should be obtained (±10 percent).

(8) Place the meter switch (M1) on the order-wire transmitter in AUDIO position. It should read between 90 and 110.

(9) Place the ac vtvm between pin K of REPEATER INTERCONN jack and ground. A reading of 1.25 volts ±0.25 volt rms should be obtained across a 330-ohm resistor.

247. Final Test of Radio Receiver

The radio receiver is tested as described below.

a. Tuneup of Crystal Multiplier. Tune up the crystal multiplier as described in paragraph 80.

b. Tuneup of Local Oscillator. Tune up the local oscillator as described in paragraph 83.

c. Afc Pull-in Range. Check the pull-in range of the afc circuit as follows:

(1) Disconnect the wavemeter rf cable at the wavemeter and connect it to the frequency meter using the cable supplied with the frequency meter and UG–914/U and UG–349A/U.

(2) Connect the oscilloscope between the junction of R143 and R144 and ground.

(3) Set the LINE VOLTS as close as possible to 115 volts.

(4) Place the AFC switch in the OFF position.

(5) Set the METER A switch to the AFC CORRECTION + position.

(6) Readjust the local oscillator INCREASE FREQ knob for an exact *zero* reading on the meter as described in paragraph 81. Note the position of this knob.

(7) Set the METER A switch to any position other than AFC CORRECTION + or AFC CORRECTION —.

(8) Set the AFC switch to the ON position.

(9) Determine and record the local oscillator frequency as measured on the frequency meter.

(10) Move the frequency dial on the frequency meter to monitor a frequency 2.0 mc higher than the local oscillator frequency as determined in (9) above.

(11) Set the METER B switch to the IF. MIXER position and place the AFC switch in the OFF position.

(12) Rotate the INCREASE FREQ knob clockwise until a buzz is heard on the frequency meter headset.

(13) Place the AFC switch to the ON position.

(14) Check the waveform on the oscilloscope to make sure that the circuit is not oscillating, that is, hunting.

(15) Determine and record the local oscillator frequency. This frequency should be within 0.25 mc of the frequency recorded in (9) above.

(16) Place the AFC switch in the OFF position.

(17) Set the frequency dial of the frequency meter to monitor a frequency 2.0 mc lower than that noted in (9) above.

(18) Rotate the INCREASE FREQ knob counterclockwise until a buzz is heard on the frequency meter handset.

(19) Place the AFC switch in the ON position.

(20) Check the waveform on the oscilloscope to make sure that the circuit is not hunting.

(21) Determine and record the local oscillator frequency. This frequency should be within 0.25 mc of the frequency recorded in (9) above.

(22) Repeat the procedures in (4) through (6) above.

(23) Change the line voltage to 103.5 volts and allow the METER A reading to stabilize.

(24) Determine and record the local oscillator frequency. This frequency should be within 3 mc of the frequency recorded in (9) above.

(25) Place the AFC switch in the ON position.

(26) Check the waveform on the oscilloscope to make sure that the circuit is not hunting.

(27) Determine and record the local oscillator frequency. This frequency should be within 0.25 mc of the frequency recorded in (9) above.

(28) Place the AFC switch in the OFF position.

(29) Change the line voltage to 126.5 volts.

(30) Set the METER A switch to the AFC CORRECTION+ position and allow the meter reading to stabilize.

(31) Repeat the procedures in (24) through (27) above.

(32) Repeat the procedures in (10) through (16) above.

(33) Change the line voltage to 103.5 volts.

(34) Set METER A switch to the AFC CORRECTION— position and allow the meter reading to stabilize.

(35) Repeat the procedures in (17) through (21) above.

(36) Tune the local oscillator as described in paragraph 83.

d. Alinement of Preselector and If. Coupling Coil. Aline the preselector and if. coupling coil as described in paragraph 240.

e. Selectivity Check. The selectivity of the receiver is checked as follows:

(1) Connect the test equipment to the receiver as shown in figure 384 and aline the receiver on channel 14.

(2) With the rf signal generator set at the crossover frequency (par. 240), adjust its output level for an IF. LEVEL meter reading of 60. (The if. signal generator output level should be zero.) Set the IF. LEVEL potentiometer fully clockwise.

(3) Set the rf signal generator to the higher of the two maximum responses (IF. LEVEL meter reading) points.

(4) Adjust the rf signal generator output for an IF. LEVEL meter reading of 70.

(5) Raise the rf signal generator output level exactly 3 db.

(6) Slowly retune the rf signal generator frequency away from the crossover frequency for an IF. LEVEL meter reading of 70.

(7) Set the if. signal generator output for maximum output level. Slowly tune the if. generator (around either 112 mc or 128 mc) until a beat is observed on the oscilloscope.

(8) Read and record the if. signal frequency. Set the if. generator output level to zero.

(9) Tune the rf signal generator past the crossover frequency to a frequency that provides an IF. LEVEL meter reading of 70.

(10) Set the if. generator for maximum out-

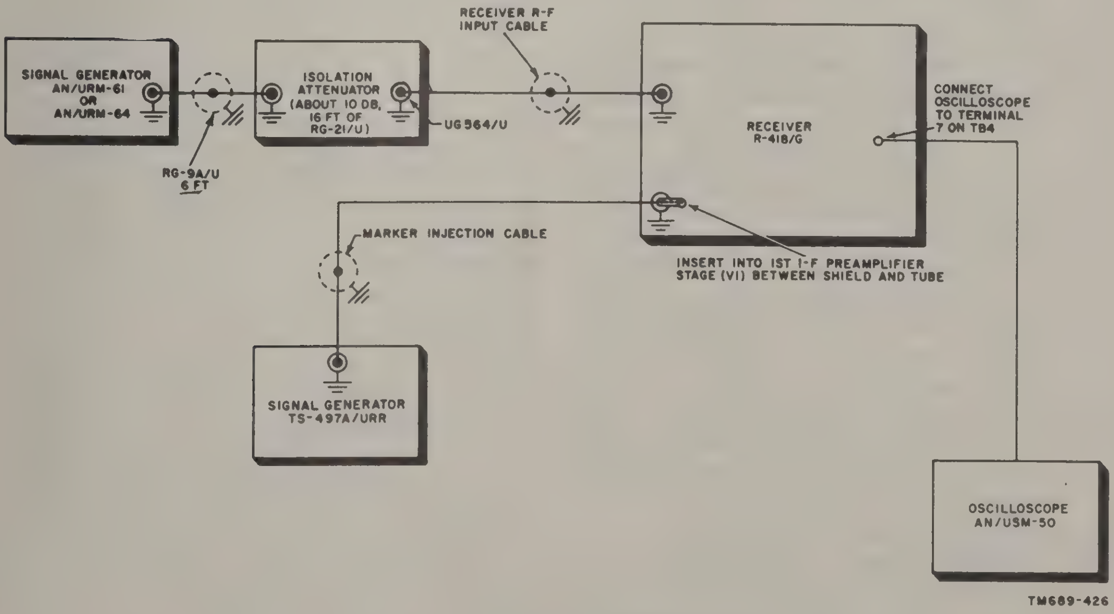

SIGNAL GENERATOR AN/URM-61 OR AN/URM-64
RG-9A/U 6 FT
ISOLATION ATTENUATOR (ABOUT 10 DB, 16 FT OF RG-21/U)
UG564/U
RECEIVER R-F INPUT CABLE
RECEIVER R-418/G
CONNECT OSCILLOSCOPE TO TERMINAL 7 ON TB4
MARKER INJECTION CABLE
INSERT INTO 1ST I-F PREAMPLIFIER STAGE (V1) BETWEEN SHIELD AND TUBE
SIGNAL GENERATOR TS-497A/URR
OSCILLOSCOPE AN/USM-50
TM689-426

Figure 384. Test setup for checking receiver selectivity.

put and slowly tune the if. generator until a beat is observed on the oscilloscope.

(11) Note and record the if. generator frequency. Set the if. generator level to zero.

(12) The 3-db bandwidth is equal to the difference between frequencies recorded in (8) and (11) above.

(13) Tune the rf generator to the crossover frequency and adjust its output level for an IF. LEVEL meter reading of 60.

(14) Read and record the rf generator attenuator setting.

(15) Set the if. generator output at a maximum, and tune the if. generator until a beat is observed on the oscilloscope.

(16) Read and record the if. generator frequency. This is the if. crossover frequency.

(17) Set the if. generator exactly 2 mc above the crossover frequency.

(18) Slowly tune the rf generator lower in frequency until a beat is observed on the oscilloscope.

(19) Set the if. generator output level to zero and adjust the rf signal generator for an IF. LEVEL meter reading of 60.

(20) Record the rf generator attenuator reading and corresponding frequency.

(21) Repeat the procedures in (18) through (20) above with the if. signal generator tuned 4, 6, 10, 14, and 16 mc above the crossover frequency.

(22) Repeat the procedures in (13), (15), and (16) above.

(23) Set the if. generator to 2 mc below crossover frequency, and repeat the procedures in (18) through (20) above, but tune the rf generator higher in frequency.

(24) Repeat the procedure in (23) above with the if. generator successively tuned to 4, 6, 10, 14, and 16 mc below crossover frequency.

(25) Plot the relative attenuator setting-difference between the settings obtained in (20) through (24) above and the setting obtained in (14) above versus frequency. The selectivity results should be in agreement with the typical selectivity curve shown in figure 385.

f. Deviation Sensitivity Output Measurement. The deviation sensitivity is measured as follows:

(1) For this test, a radio transmitter known to be operating properly is used to provide the required signal to the radio receiver. The procedure for connecting the transmitter to receiver is described in (2) through (6) below.

(2) Connect the radio set for normal station operation as described in paragraphs 53 through 63.

(3) Connect the RF TEST OUTPUT (–65 to –71 DB) on the back of the radio transmitter through a 20-db cable also mounted on the back of the radio transmitter to the ANT. terminal on the back of the radio receiver. Dis-

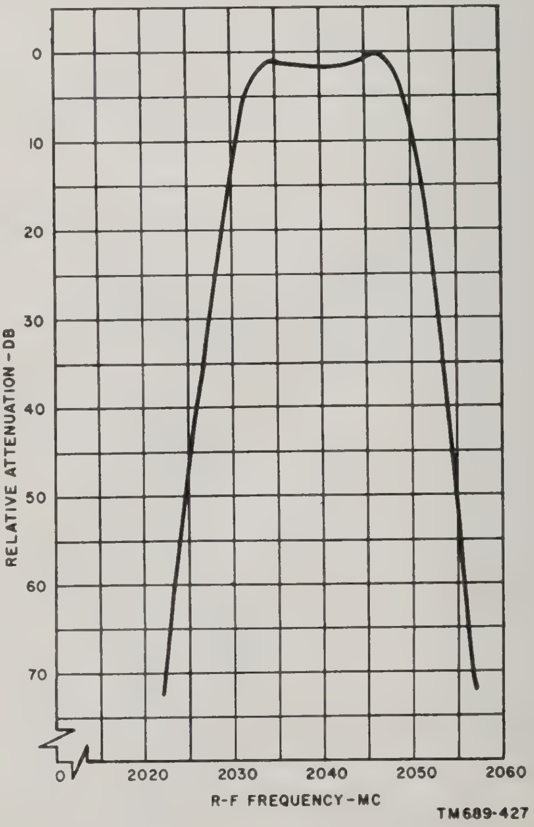


Figure 385. Receiver selectivity curve.

connect the receiver input cable from the duplexer and connect it to the RF REC IN terminal.

(4) Disconnect the cable connected to the VIDEO OUTPUT receptacle on the order-wire receiver. Connect the vtvm across 50-ohm resistor placed between the VIDEO OUTPUT receptacle and ground.

(5) Connect the Audio Oscillator TS-382/U output through a 560-ohm resistor to the VIDEO INPUT jack of the radio transmitter (fig. 386).

(6) Set the controls in the radio set to the following positions:

- (*a*) PLATE (order-wire transmitter) in the OFF position.
- (*b*) MOD INPUT SEL SW (radio transmitter) in the VID position.
- (*c*) VIDEO LEVEL (radio transmitter) in the fully clockwise position.
- (d) VTVM SEL SW (radio transmitter) in the MON OUT position.
- (*e*) BUZZER CONTROL (order-wire receiver) in the MONITOR position.

(7) Turn on the radio set.

(8) Set the audio oscillator frequency to 10 kc and adjust the output level for a peak VTVM reading of 100 percent.

(9) Set the VIDEO LEVEL potentiometer in the radio receiver to its maximum clockwise position.

(10) A reading between 0.56 and 0.64 volt rms should be obtained on the vtvm connected across the VIDEO OUTPUT.

(11) Rotate the VIDEO LEVEL potentiometer in the radio receiver until an rms video output level of 0.4 volt is obtained.

g. Signal-to-Noise Measurements. The receiver signal-to-noise ratio is measured as follows:

(1) Connect the equipment and adjust the VIDEO LEVEL potentiometer for a 0.4-volt output as described in *f* above.

(2) Connect the input terminals of an oscilloscope across the VIDEO OUTPUT terminating resistor and mark the amplitude of the waveform on the face of the cathode-ray tube (A, fig. 388).

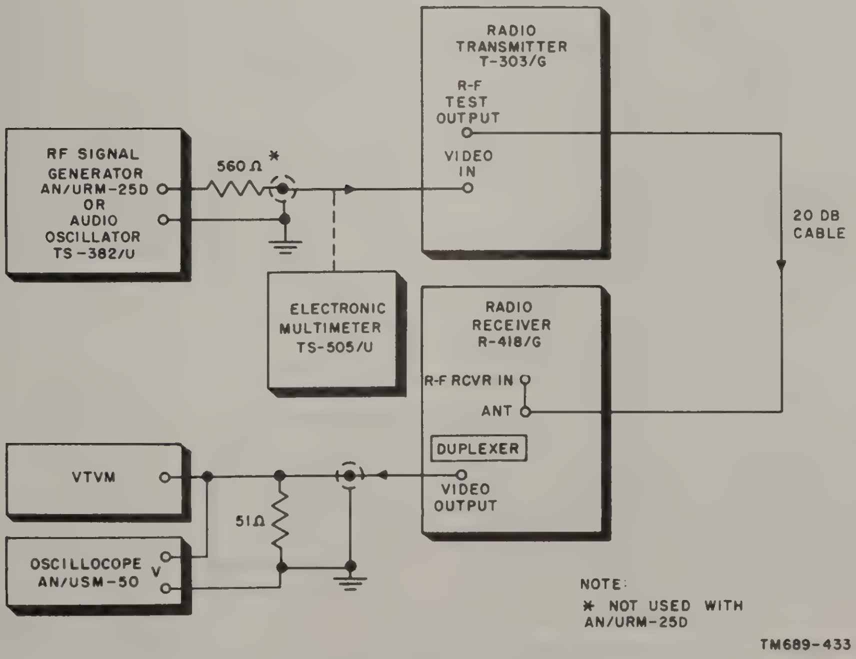

RADIO TRANSMITTER T-303/G
R-F TEST OUTPUT
VIDEO IN
RF SIGNAL GENERATOR AN/URM-25D OR AUDIO OSCILLATOR TS-382/U
560 Ω *
20 DB CABLE
ELECTRONIC MULTIMETER TS-505/U
RADIO RECEIVER R-418/G
R-F RCVR IN
ANT
DUPLEXER
VIDEO OUTPUT
VTVM
51 Ω
OSCILLOCOPE AN/USM-50
V
NOTE:
* NOT USED WITH AN/URM-25D
TM689-433

Figure 386. Test setup for deviation and signal-to-noise ratio measurements.

Note the setting of the vertical gain controls.

(3) Without disturbing the setting of the oscilloscope vertical gain controls, connect an rf signal generator to the receiver as shown in figure 387.

(4) The signal-to-noise ratio of the receiver is determined as follows: vary the vertical gain of the oscilloscope by a small amount (that is, 10 to 1 or 100 to 1) for a setting that increases the *main level* (B, fig. 388) of the noise to the point where it becomes comparable with amplitude marks as indicated in (2) above. Now it should be possible to determine signal-to-noise ratio on the oscilloscope screen. By multiplying this ratio by the increased vertical gain setting, the receiver signal-to-noise ratio can be determined.

(5) With the signal generator off, note the noise level reading on the oscilloscope. This voltage should be between 200 and 400 millivolts.

(6) Turn on the signal generator and set its frequency to the crossover frequency (par. 240). Set its output level to the point where the noise level no longer decreases with increasing the carrier level.

(7) Record both the signal generator output level and signal-to-noise ratio obtained as indicated in (6) above and explained in (4) above.

(8) Lower the signal generator output 6 db from its previous setting.

(9) Read and record both the signal generator level and signal-to-noise ratio.

(10) Repeat the procedures in (8) and (9) above until the IF. LEVEL meter reading decreases to 50.

(11) Convert the signal-to-noise ratio as determined on the oscilloscope into db. Add 12 db to this number when noise as viewed on the oscilloscope screen is primarily random (white) noise. When the noise as seen on the oscilloscope is primarily hum, the correction factor is not necessary.

(12) Divide each signal generator output level recorded by 3.18 to convert to the receiver input level.

(13) Plot results (with the 12-db correction factor) on graph paper as illustrated in figure 389. The results should be in close agreement with the typical signal-to-noise ratio curve given in figure 389. The 12-db correction factor is necessary to compensate for the reduced energy content present in random noise. Since a wide-band ac vtvm responds to the energy content of the signal, this correction factor is not necessary if such a wide-band meter is used to measure the noise level.

(14) If a wide-band ac vtvm, such as the voltmeter ME–30/U, having an essentially flat frequency response to at least 6 mc and capable of reading levels as low as 1 millivolt, is available, then the signal-to-noise ratio may be measured directly and the plotted results should be in close agreement with the curve given in figure 389.

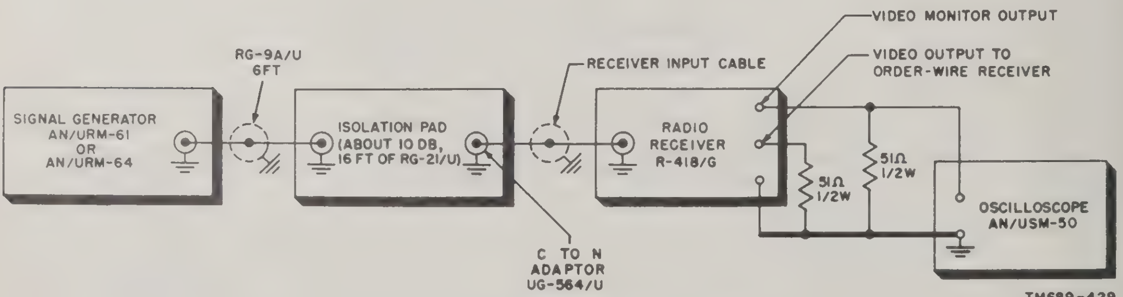
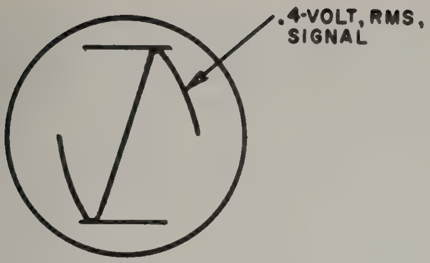
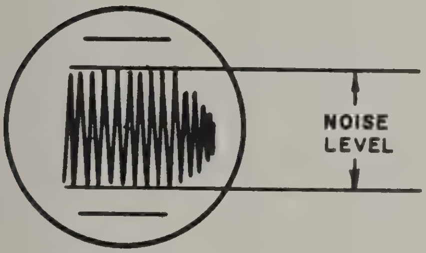


Figure 387. Test setup for signal-to-noise measurements.



A. CALIBRATION OF OSCILLOSCOPE



B. ADJUSTMENT OF NOISE LEVEL

TM 689-490

Figure 388. Signal-to-noise measurement on oscilloscope.

248. Final Test and Adjustment of Power Supply PP–690/G

The receiver power supply is checked and adjusted as follows:

a. Check the terminal board resistances to ground (fig. 339).

b. Place all receiver circuit breakers in ON position as well as the INPUT POWER BREAKER switches on the back of the high-voltage power supply. Allow a 10-minute warm-up period. Disconnect cable between the if. preamplifier and the if. amplifier.

c. Adjust the line voltage for a LINE VOLTS reading as close as possible to 115 volts.

d. With the multimeter, check the voltage between terminal 2 of TB3 and ground. If it is not +250 volts dc, adjust the +250V ADJ control for a 250-volt reading.

e. With the multimeter, check voltage between terminal 3 of TB3 and ground. If it is not +150 volts dc, adjust +150V ADJ control for a 150-volt reading.

f. Connect the ac vtvm and oscilloscope to terminal 2 of TB3 and ground and measure the ripple voltage. The ripple voltage should not exceed 10 millivolts.

g. Vary the line voltage to 103.5 volts. The dc output voltage should not exceed +250.5 volts and the ripple voltage should not exceed 10 millivolts.

h. Vary the line voltage to 126.5 volts. The dc output voltage should not go below 249.2 volts and the ripple voltage should not exceed 10 millivolts.

i. Vary the line voltage to 115 volts. Connect the multimeter, ac vtvm, and oscilloscope between terminal 3 of TB3 and ground. The ripple voltage should not exceed 1 millivolt.

j. Vary the line voltage to 103.5 volts. The dc output voltage should not exceed 150.25 volts and the ripple voltage should not exceed 1 millivolt.

k. Vary the line voltage to 126.5 volts. The dc output voltage should not go below 149.75 volts and the ripple voltage should not exceed 1 millivolt.

l. Vary the line voltage to 115 volts and connect the multimeter, vtvm and oscilloscope between terminal 4, TB3, and ground. The dc output voltage should be +42 volts ±5 volts. The ripple voltage should not exceed 1 millivolt.

m. Vary the line voltage to 103.5 volts. The dc output voltage should not increase more than 0.5 volt above the value measured as indicated in *l* above, and the ripple voltage should not exceed 1 millivolt.

n. Vary the line voltage to 126.5 volts. The dc output voltage should not drop more than 0.5 volt below the value measured as indicated in *l* above and, the ripple voltage should not exceed 1 millivolt.

o. Vary the line voltage to 115 volts. Connect the multimeter, vtvm, and oscilloscope between terminal 5 of TB3 and ground. If dc output voltage is not —300 volts, refer to the procedure given in paragraph 239. The ripple voltage should not exceed 150 millivolts.

p. Vary the line voltage to 103.5 volts. The dc output voltage should not go below 270 volts, and the ripple voltage should not exceed 150 millivolts.

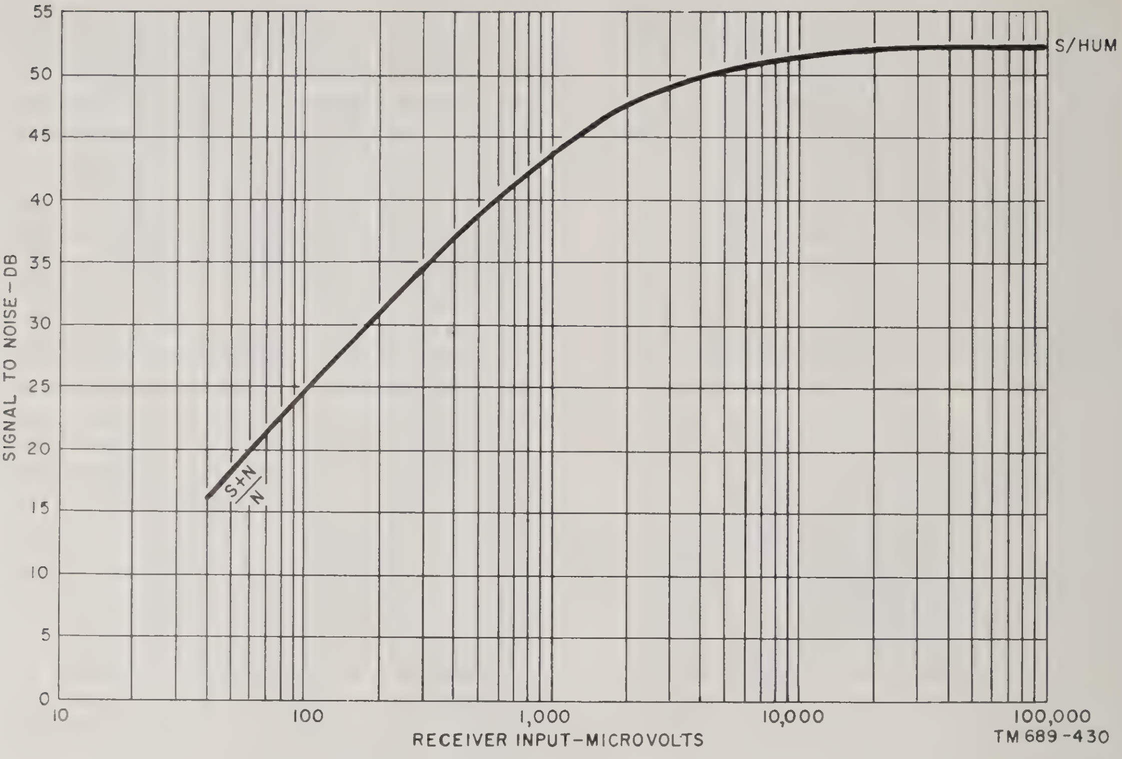


Figure 389. Receiver signal-to-noise ratio curve.

q. Vary the line voltage to 126.5 volts. The dc output voltage should not exceed 330 volts, and the ripple voltage should not exceed 150 millivolts.

r. Vary the line voltage to 115 volts. Connect the multimeter, vtvm, and oscilloscope between terminal 6 and ground. The dc output voltages should be —475 volts ±8 volts. The ripple voltage should not exceed 150 millivolts.

s. Vary the line voltage to 103.5 volts. The dc output voltage should not change more than 35 volts from the value noted in *r* above. The ripple should not exceed 150 millivolts.

t. Vary the line voltage to 126.5 volts. The dc output voltage should not change more than 35 volts from the value noted in *r* above. The ripple voltage should not exceed 150 millivolts.

u. Vary the line voltage to 115 volts. Connect the multimeter, vtvm, and oscilloscope between terminal 7, TB3, and ground. The dc output voltage should be —625 volts ±10 volts. The ripple voltage should not exceed 150 millivolts.

v. Vary the line voltage to 103.5 volts. The dc output voltage should not change more than 35 volts from the value noted in *u* above. The ripple voltage should not exceed 150 millivolts.

w. Vary the line voltage to 126.5 volts. The dc output voltage should not change more than 35 volts from the value noted in *u* above. The ripple voltage should not exceed 150 millivolts.

x. Reconnect the if. amplifier cable.

249. Final Test and Adjustment of Power Supply PP–689/G

The transmitter low-voltage supply is checked and adjusted as follows:

a. Place all transmitter circuit breakers in the ON position except the PA PLATE and KLYSTRON HV circuit breakers. Allow a 10-minute warmup period.

b. Adjust the line voltage for a LINE VOLTS reading as close as possible to 115 volts.

c. With the multimeter, check the voltage between terminal D of jack J1 and ground. If it is not +300 volts, adjust the +300V ADJ control for a 300-volt reading.

d. Connect the ac vtvm and oscilloscope between terminal D, jack J1, and ground. The ripple voltage should not exceed 10 millivolts.

e. Vary the line voltage to 103.5 volts. The dc output voltage should not go below 295 volts, and the ripple voltage should not exceed 10 millivolts.

f. Vary the line voltage to 126.5 volts. The dc output voltage should not exceed 305 volts, and the ripple voltage should not exceed 10 millivolts.

g. Vary the line voltage to 115 volts. Connect the multimeter, vtvm, and oscilloscope between terminal C, jack J1, and ground. If the dc output voltage is not +250 volts, adjust the +250V ADJ control for a 250-volt reading. Ripple voltage should not exceed 13 millivolts.

h. Vary the line voltage to 103.5 volts. The dc output voltage should not go below 245 volts, and the ripple voltage should not exceed 13 millivolts.

i. Vary the line voltage to 126.5 volts. The dc output voltage should not exceed 255 volts, and the ripple voltage should not exceed 13 millivolts.

j. Vary the line voltage to 115 volts. Connect the multimeter, vtvm, and oscilloscope between terminal B, jack J1, and ground. Adjust the +150V ADJ control for a 150-volt reading. The ripple voltage should not exceed 12 millivolts.

k. Vary the line voltage to 103.5 volts. The dc output voltage should not go below 147 volts, and the ripple voltage should not exceed 12 millivolts.

l. Vary the line voltage to 126.5 volts. The dc output voltage should not exceed 153 volts, and the ripple voltage should not exceed 12 millivolts.

m. Vary the line voltage to 115 volts. Connect the multimeter, vtvm, and oscilloscope between terminal F, jack J1, and ground. The dc output voltage should be +42 volts ±5 volts. The ripple voltage should not exceed 12 millivolts.

n. Vary the line voltage to 103.5 volts. The dc output voltage should not change more than 3 volts from the value noted in *m* above. The ripple voltage should not exceed 12 millivolts.

o. Vary the line voltage to 126.5 volts. The dc output voltage should not change more than 3 volts from the value noted in *m* above. The ripple voltage should not exceed 12 millivolts.

p. Vary the line voltage to 115 volts. Connect the multimeter, vtvm, and oscilloscope between terminal A, jack J1, and ground. The dc output voltage should be —150 volts ±5 volts, and the ripple voltage should not exceed 90 millivolts.

q. Vary the line voltage to 103.5 volts. The dc output voltage should not change, and the ripple voltage should not exceed 90 millivolts.

r. Vary the line voltage to 126.5 volts. The dc output voltage should not change, and the ripple voltage should not exceed 90 millivolts.

250. Final Test and Adjustment of Radio Set AN/TRC–29

Some of the final tests and adjustments of the components in Radio Set AN/TRC–29 must be made on an overall equipment basis. In addition, the equipment must be tuned and adjusted to operate in the radio relay system. The tests and adjustments required are described below.

a. Transmitter Level Check. To check the transmitter level, proceed as follows:

(1) Connect the radio set for normal station operation as described in paragraphs 53 through 64.

(2) Connect RF TEST OUTPUT (—65 to —71 DB) jack at the back of the radio transmitter, through 20–db cable mounted on the rear cover of the radio transmitter, to the ANT. terminal on the back of the radio receiver. Disconnect the receiver input cable from the duplexer and connect it to the RF REC INPUT terminal.

(3) Disconnect the cable connected to the VIDEO OUTPUT receptacle on the order-wire receiver. Connect the ac vtvm across 50-ohm resistor placed between the VIDEO OUTPUT receptacle and ground.

(4) Connect Audio Oscillator TS–382/U output through a 560-ohm resistor to the VIDEO IN jack of the radio transmitter (fig. 386). Connect the vtvm across VIDEO IN terminal.

(5) Set the controls in the radio set to the following positions:

(*a*) PLATE (order-wire transmitter) in the OFF position.

(*b*) MOD INPUT SEL SW (radio transmitter) in the VID position.

(*c*) INPUT VIDEO LEVEL (radio transmitter) in the fully clockwise position.

(*d*) VTVM SEL SW (radio transmitter) in the MON OUT position.

(*e*) BUZZER CONTROL (order-wire receiver) in MONITOR position.

(6) Set the signal generator frequency to 10 kc and adjust its output level for a 0.5-volt reading on the vtvm connected across the VIDEO OUTPUT jack.

(7) The video input signal level, as read on the vtvm, should be 158 millivolts or less.

(8) The PEAK VTVM meter reading on the radio transmitter should be about 125 percent (modulation).

b. Radio Set Frequency Response. The frequency response of the radio set is measured as follows:

(1) Connect the test equipment to the radio set as described in *a* above.

(2) Set the Signal Generator TS–382/U to 10 kc and adjust its output level for a 30 percent reading on the PEAK VTVM meter.

(3) Note the input level reading on the vtvm.

(4) Maintain the signal input level at the value noted in (3) above, and vary the input frequency from 30 cps to 5.0 mc, noting the VIDEO OUTPUT voltage for each frequency, in the following small steps: 30 cps, 100 cps, 1,000 cps, 10 kc, 1.0 mc, 2.0 mc, 3.0 mc, 4.0 mc, and 5.0 mc.

Note. Use RF Signal Generator AN/URM–25D for frequencies above 20 kc as described in paragraph 233*d*(5). When available, a signal generator, such as the Hewlett-Packard 650A or military equivalent should be used for covering the entire frequency range.

(5) The output voltage should be constant, within 3 db, for all readings noted in (4) above.

c. Operational Test and Adjustment. The radio set now should be tuned and adjusted for operation in the radio relay system as described in paragraphs 65 through 72 and paragraphs 85 through 101.

CHAPTER 8

SHIPMENT AND LIMITED STORAGE AND DEMOLITION TO PREVENT ENEMY USE

Section I. SHIPMENT AND LIMITED STORAGE

251. Disassembly

The following instructions are recommended as a guide for preparing the radio set for transportation and storage.

a. Make sure all power switches are in the off position.

b. Disconnect all interconnecting power and signal cables, and store them in Chest CY–250/U. Cord CG–409C/U (2 ft 6 in.) is left in place in the transmitter rack and Cord CG–409C/U (1 ft 7 in.) is left in place in the receiver rack.

c. Wind up the 150-foot length of Electrical Power Cable Assembly CX–2440/U on Reel RC–405/TR.

d. Remove the transmitter klystron, transmitter and receiver crystals, and duplexer by reversing the instructions in paragraph 51. Store them in the boxes in which they were shipped.

e. Replace the dummy klystron in the transmitter as instructed in paragraph 133.

f. Fasten the front and rear covers of the transmitter and receiver racks.

g. Remove Antenna AS–554/TRC–29 from Tower AB–216/U as follows:

(1) Remove Radio Frequency Transmission Line Assembly CG–1013/U by reversing the instructions given in paragraph 50. Pack the cable in shipping cases.

(2) Remove the pipe stay bars and lower them to the ground. Use the swivel clamps to secure the rope.

(3) Tilt the dish downward and remove the feed-horn assembly. Use a tag line when lowering the feed horn.

(4) Tilt the dish upward and lock.

(5) Attach the hoist line to the lifting shackle and two tag lines to the left and right tilt bearing casting.

(6) Take up the slack in the hoist rope and loosen the A-frame post clamps, the bottom one first.

(7) Lower the antenna assembly to the ground (fig. 390).

(8) Place the antenna assembly face down and disassemble it by reversing the instructions given in paragraph 49.

(9) Lower A-frame using tag lines.

(10) Pack all antenna parts in their proper places as shown in the parts packing lists on each chest. Figure 15 shows the antenna packed in the shipping cases.

h. Disassemble Tower AB–216/U by following the procedures given in TM 11–5073.

i. Pack all parts of the tower in shipping cases.

252. Repacking for Shipment or Limited Storage

a. The exact procedure in repacking for shipment or limited storage depends on the material available and the conditions under which the equipment is to be shipped or stored. Refer to paragraph 47, and reverse the instructions given in this paragraph.

b. Whenever practicable, place a dehydrating agent, such as silica gel inside the crates. Protect the cases with a waterproof paper barrier. Seal the seams of the paper barrier with waterproof sealing compound or tape. Pack the pro-

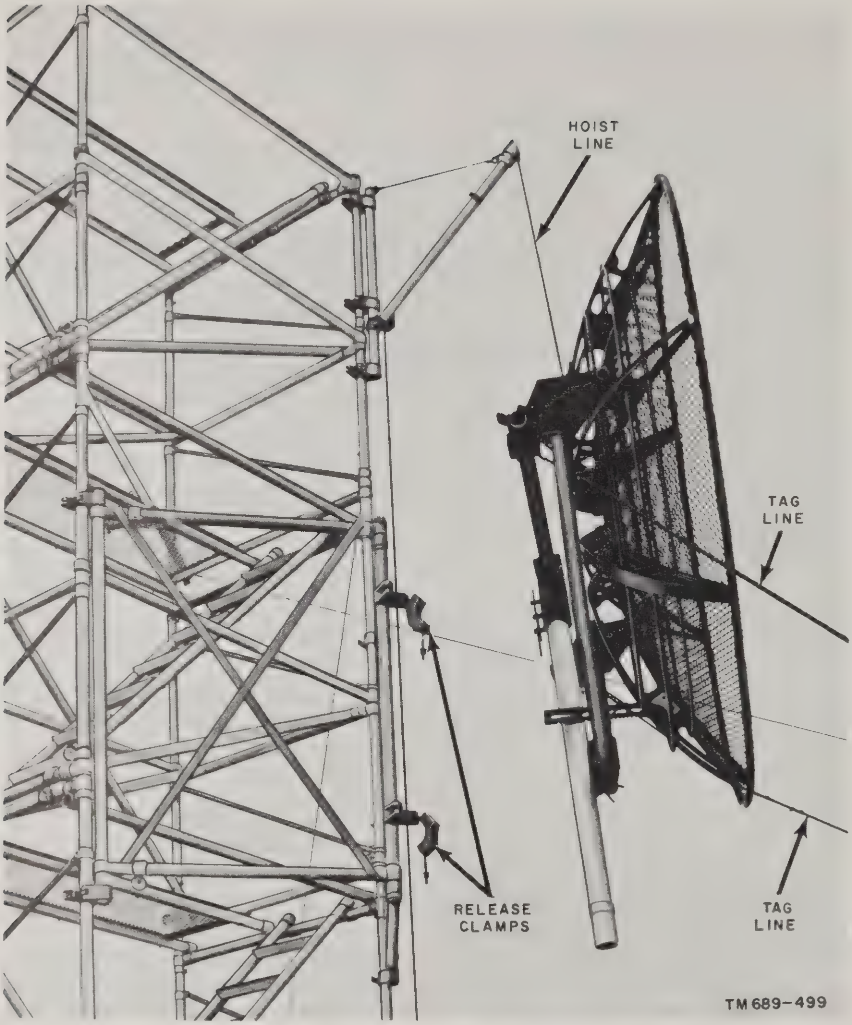


Figure 390. Disassembly of antenna.

tected cases in a padded wooden crate; provide at least 3 inches of excelsior padding or some similar material between the paper barrier and the packing crate.

Section II. DEMOLITION OF MATERIEL TO PREVENT ENEMY USE

253. General

Use any or all the methods outlined in paragraph 254 to prevent the enemy from using or salvaging this equipment. This will be accomplished only upon order of the commander.

254. Methods of Destruction

Completely destroy the equipment as follows:

a. Smash. Smash the crystals, tubes, coils, switches, capacitors, transformers, and handsets; use sledges, axes, handaxes, pickaxes, hammers, crowbars, or heavy tools.

b. Cut. Cut cords, cables, and wiring; use axes, handaxes, or machetes.

c. Burn. Burn cords, cables, wiring, resistors, capacitors, coils, and technical manuals; use gasoline, kerosene, oil, flamethrowers, or incendiary grenades.

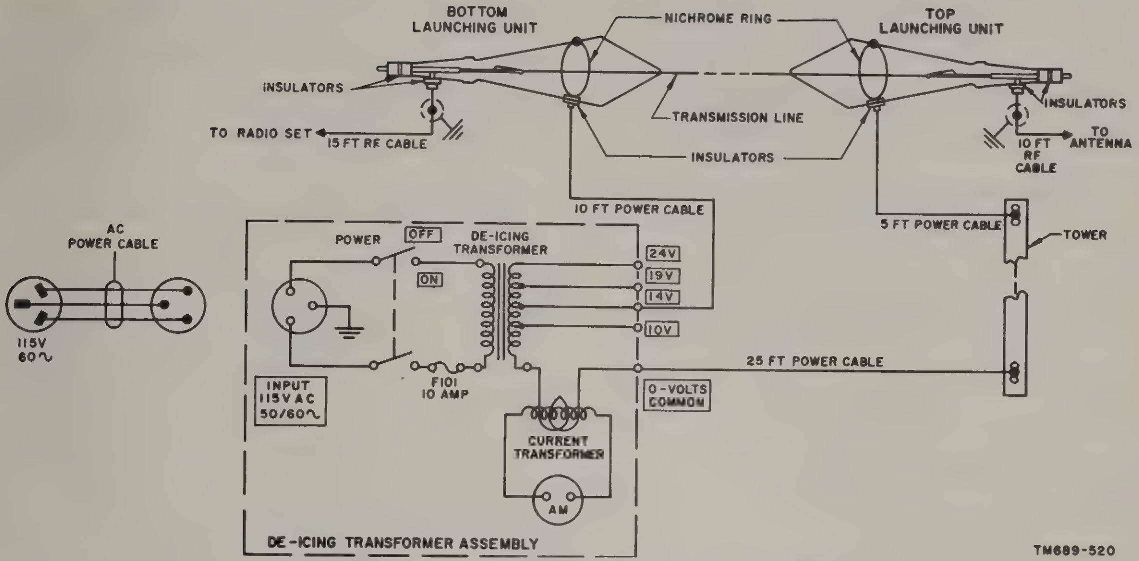

BOTTOM LAUNCHING UNIT
NICHROME RING
TOP LAUNCHING UNIT
INSULATORS
TRANSMISSION LINE
INSULATORS
TO RADIO SET
15 FT RF CABLE
INSULATORS
TO ANTENNA
10 FT RF CABLE
10 FT POWER CABLE
5 FT POWER CABLE
TOWER
AC POWER CABLE
115V 60~
POWER
OFF
ON
DE-ICING TRANSFORMER
24V
19V
14V
10V
25 FT POWER CABLE
INPUT 115VAC 50/60~
F101 10 AMP
0-VOLTS COMMON
CURRENT TRANSFORMER
AM
DE-ICING TRANSFORMER ASSEMBLY
TM689-520

Figure 393. Surface-wave transmission linc, schematic diagram.

d. Bend. Bend panels, cabinets, chassis, antenna and tower structures.

e. Explode. If explosives are necessary, use grenades, or TNT.

f. Dispose. Bury or scatter the destroyed parts in slit trenches, fox holes, or other holes, or throw them into streams.

Figure 391. Order-wire receiver, radio receiver, and receiver power supply, intercomponent cabling diagram.
(Contained in separate envelope)

Figure 392. Radio Receiver R–418/G, overall schematic diagram.
(Contained in separate envelope)

Figure 394. Radio Receiver R–418/G, afc, schematic diagram.
(Contained in separate envelope)

Figure 395. Radio Receiver R–418/G, preamplifier, schematic diagram.
(Contained in separate envelope)

Figure 396. Radio Receiver R–418/G, if., schematic diagram.
(Contained in separate envelope)

Figure 399. Order-Wire Receiver R–543/TRC–29, overall schematic diagram.
(Contained in separate envelope)

Figure 400. Power Supply PP–690/G, overall schematic diagram.
(Contained in separate envelope)

Figure 401. Radio Transmitter T–303/G, interunit cabling diagram.
(Contained in separate envelope)

Figure 402. Radio Transmitter T–303/G, overall schematic diagram.
(Contained in separate envelope)

Figure 403. Radio Transmitter T–303/G, modulator, schematic diagram.
(Contained in separate envelope)

Figure 405. Radio Transmitter T–303/G, if. schematic diagram.
(Contained in separate envelope)

Figure 406. Radio Transmitter T–303/G, chopper, schematic diagram.
(Contained in separate envelope)

Figure 407. Radio Transmitter T–303/G, vtvm, schematic diagram.
(Contained in separate envelope)

Figure 408. Radio Transmitter T–303/G, meter panel, schematic diagram.
(Contained in separate envelope)

Figure 410. Order-Wire Transmitter T–389/TRC–29, overall schematic diagram.
(Contained in separate envelope)

Figure 411. Power Supply PP–764/G, overall schematic diagram.
(Contained in separate envelope)

Figure 412. Power Supply PP–689/G, overall schematic diagram.

(Contained in separate envelope)

Figure 413. Radio Receiver R–418/G, overall wiring diagram.

(Contained in separate envelope)

Figure 414. Radio Receiver R–418/G, afc, wiring diagram.

(Contained in separate envelope)

Figure 415. Radio Receiver R–418/G, preamplifier, wiring diagram.

(Contained in separate envelope)

Figure 416. Radio Receiver R–418/G, if., overall wiring diagram.

(Contained in separate envelope)

Figure 417. Radio Receiver R–418/G, video amplifier, wiring diagram.

(Contained in separate envelope)

Figure 419. Order-Wire Receiver R–543/TRC–29, overall wiring diagram.

(Contained in separate envelope)

Figure 420. Power Supply PP–690/G, overall wiring diagram.

(Contained in separate envelope)

Figure 421. Radio Transmitter T–303/G, overall wiring diagram.

(Contained in separate envelope)

Figure 423. Radio Transmitter T–303/G, modulator, wiring diagram.

(Contained in separate envelope)

Figure 425. Radio Transmitter T–303/G, if., wiring diagram.

(Contained in separate envelope)

Figure 426. Radio Transmitter T–303/G, chopper, wiring diagram.

(Contained in separate envelope)

Figure 427. Radio Transmitter T–303/G, vtvm, wiring diagram.

(Contained in separate envelope)

Figure 428. Radio Transmitter T–303/G, meter panel, wiring diagram.

(Contained in separate envelope)

Figure 430. Order-Wire Transmitter T–389/TRC–29, overall wiring diagram.

(Contained in separate envelope)

Figure 431. Power Supply PP–764/G, overall wiring diagram

(Contained in separate envelope)

Figure 432. Power Supply PP–689/G, overall wiring diagram.

(Contained in separate envelope)

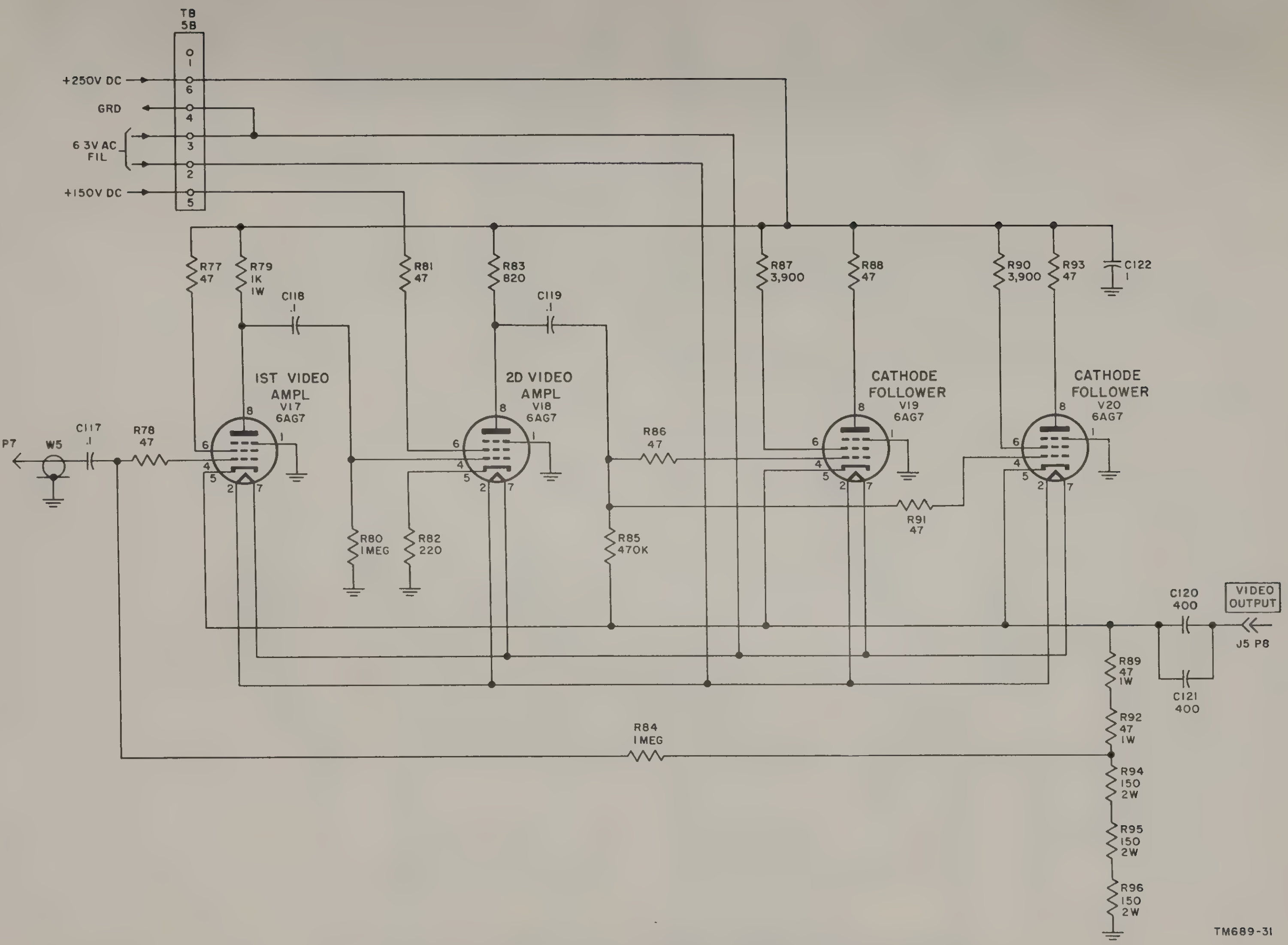
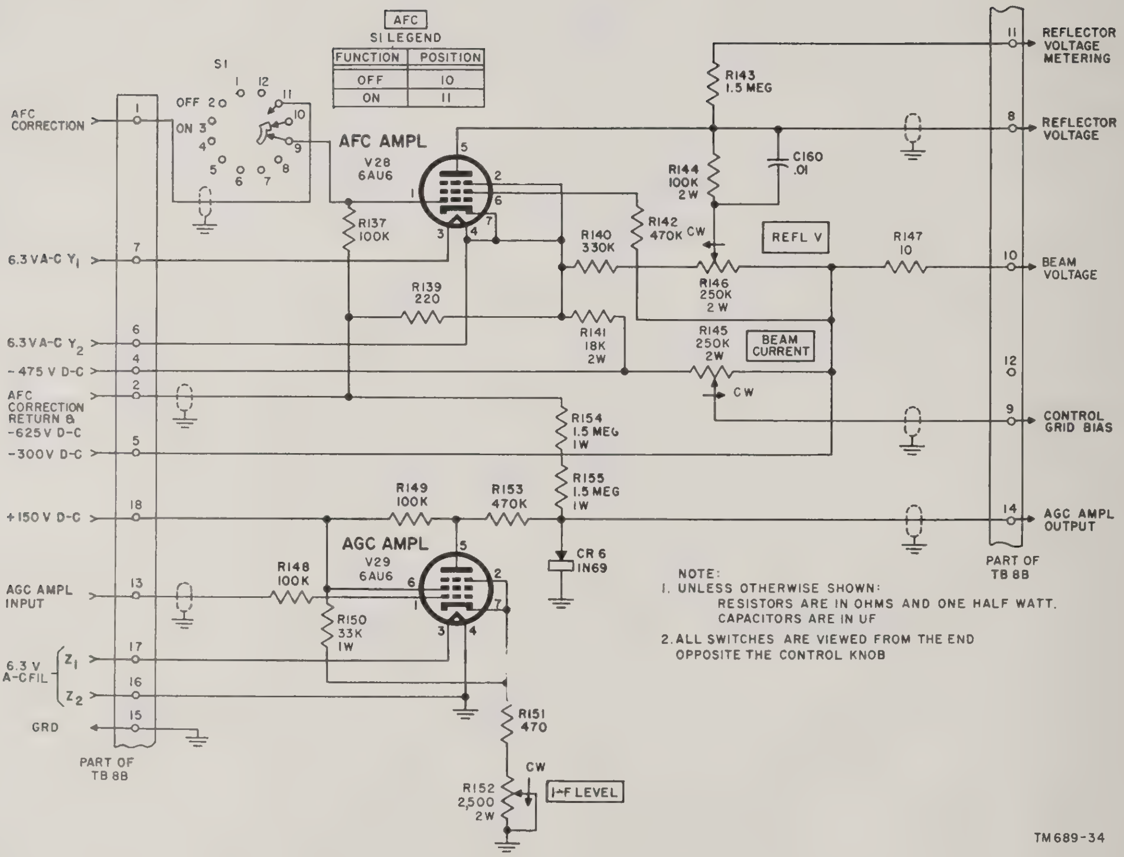

TB
5B
+250V DC
GRD
6 3V AC
FIL
+150V DC
1
6
4
3
2
5
R77
47
R79
1K
1W
C118
.1
R81
47
R83
820
C119
.1
R87
3,900
R88
47
R90
3,900
R93
47
C122
1
1ST VIDEO
AMPL
V17
6AG7
2D VIDEO
AMPL
V18
6AG7
CATHODE
FOLLOWER
V19
6AG7
CATHODE
FOLLOWER
V20
6AG7
P7
W5
C117
.1
R78
47
R86
47
R91
47
R80
1MEG
R82
220
R85
470K
C120
400
C121
400
VIDEO
OUTPUT
J5 P8
R89
47
1W
R92
47
1W
R84
1MEG
R94
150
2W
R95
150
2W
R96
150
2W
TM689-31

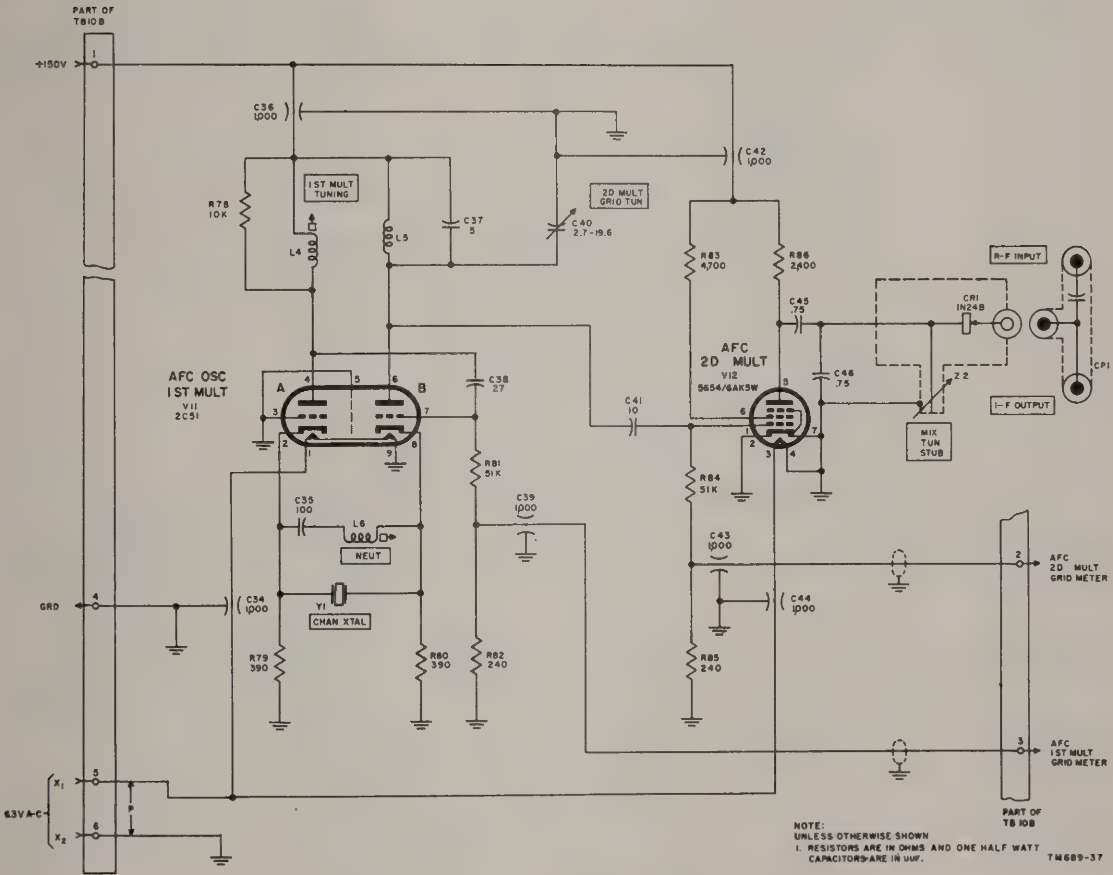
Figure 397. Radio Receiver R–418/G, video amplifier, schematic diagram.


AFC
S1 LEGEND
S1
1
12
11
10
9
8
7
6
5
4
ON 3
OFF 2
AFC CORRECTION
AFC AMPL
V28
6AU6
R137
100K
6.3 VA-C Y1
R139
220
6.3 VA-C Y2
-475 V D-C
AFC CORRECTION RETURN & -625 V D-C
-300V D-C
+150 V D-C
AGC AMPL INPUT
6.3 V A-C FIL
Z1
Z2
GRD
PART OF TB 8B
R143
1.5 MEG
R144
100K
2W
C160
.01
R142
470K
R140
330K
CW
REFL V
R146
250K
2 W
R141
18K
2W
R145
250K
2W
BEAM CURRENT
R147
10
R154
1.5 MEG
1W
R155
1.5 MEG
1W
R149
100K
R153
470K
CR 6
1N69
AGC AMPL
V29
6AU6
R148
100K
R150
33K
1W
R151
470
R152
2,500
2W
I-F LEVEL
REFLECTOR VOLTAGE METERING
REFLECTOR VOLTAGE
BEAM VOLTAGE
CONTROL GRID BIAS
AGC AMPL OUTPUT
PART OF TB 8B
TM689-34

FUNCTION	POSITION
OFF	10
ON	11

NOTE:
1. UNLESS OTHERWISE SHOWN:
   RESISTORS ARE IN OHMS AND ONE HALF WATT.
   CAPACITORS ARE IN UF
2. ALL SWITCHES ARE VIEWED FROM THE END OPPOSITE THE CONTROL KNOB

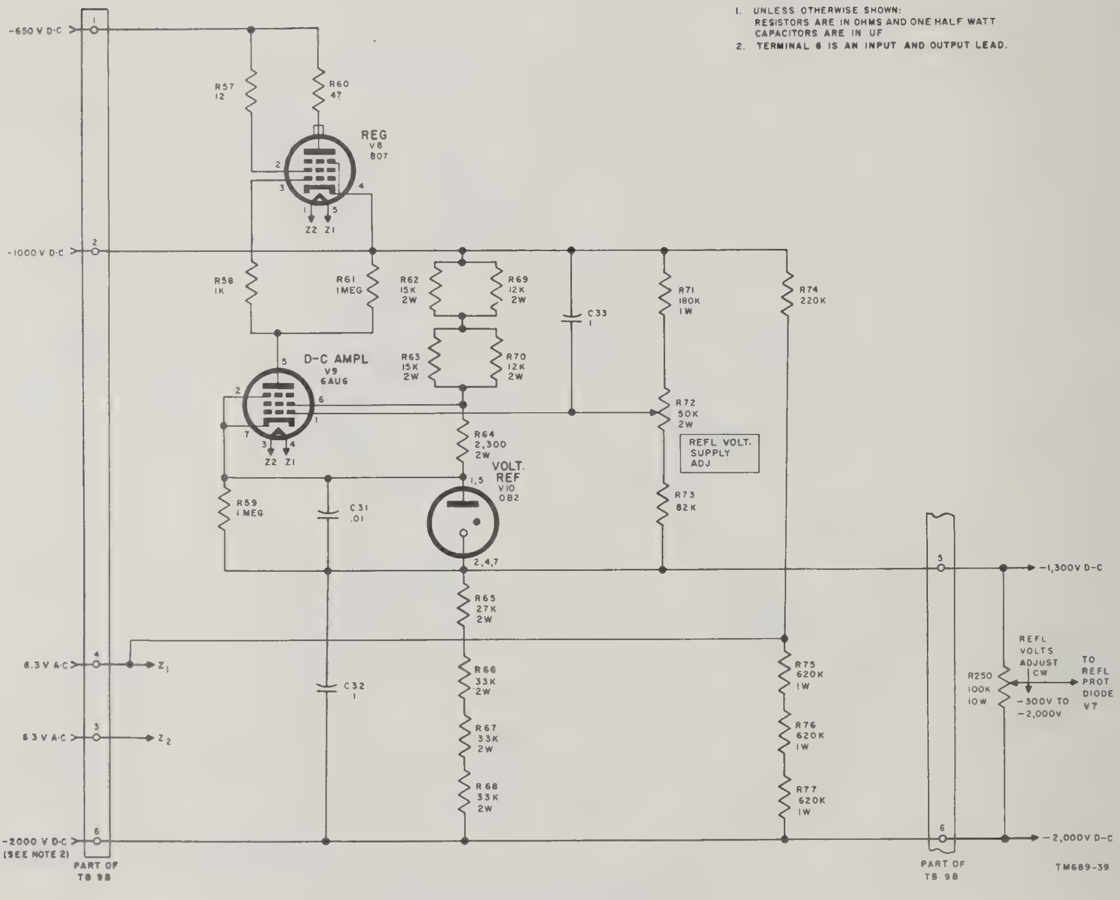
Figure 398. Radio Receiver R–418/G, afc and agc dc amplifier, schematic diagram.


PART OF
TB10B
+150V
1
C36
1,000
C42
1,000
1ST MULT
TUNING
2D MULT
GRID TUN
R78
10K
L4
L5
C37
5
C40
2.7-19.6
R83
4,700
R86
2,400
R-F INPUT
C45
.75
CR1
1N24B
AFC
2D MULT
V12
5654/6AK5W
C46
.75
Z2
CP1
I-F OUTPUT
MIX
TUN
STUB
AFC OSC
1ST MULT
V11
2C51
A
B
C38
27
C41
10
R81
51K
R84
51K
C35
100
L6
NEUT
C39
1,000
C43
1,000
C44
1,000
GRD
4
C34
1,000
Y1
CHAN XTAL
R79
390
R80
390
R82
240
R85
240
2
AFC
2D MULT
GRID METER
3
AFC
1ST MULT
GRID METER
X1
5
63VA-C
X2
6
P
PART OF
TB 10B

NOTE:
UNLESS OTHERWISE SHOWN
1. RESISTORS ARE IN OHMS AND ONE HALF WATT
CAPACITORS ARE IN UUF.

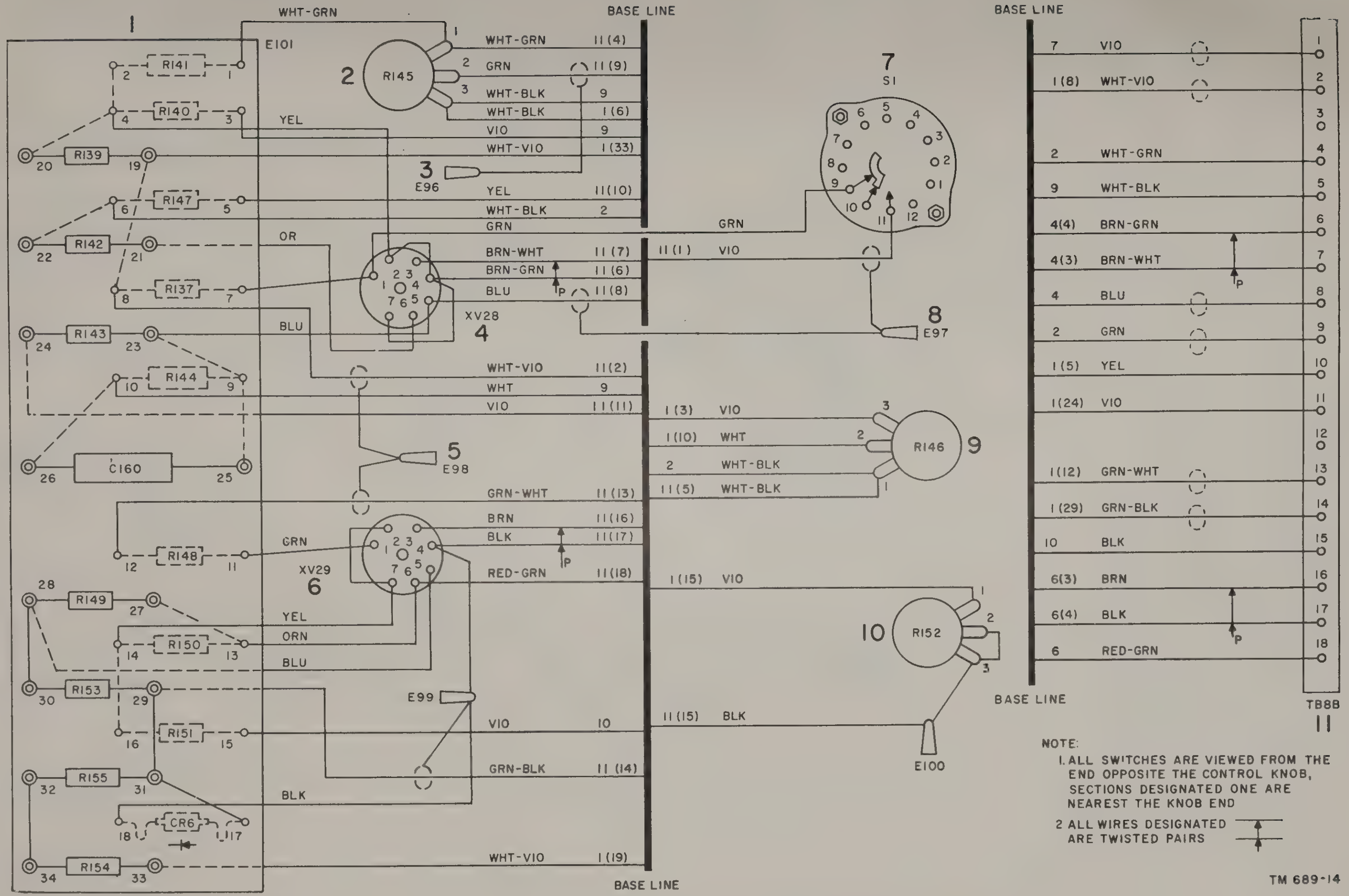
TM689-37

Figure 404. Radio Transmitter T–303/G, crystal multiplier, schematic diagram.


-650 V D-C
1
R57
12
R60
47
REG
V8
807
2
3
4
1
5
Z2
Z1
-1000 V D-C
2
R58
1K
R61
1MEG
R62
15K
2W
R69
12K
2W
C33
1
R71
180K
1W
R74
220K
D-C AMPL
V9
6AU6
5
2
6
1
7
3
4
Z2
Z1
R63
15K
2W
R70
12K
2W
R72
50K
2W
REFL VOLT.
SUPPLY
ADJ
R64
2,300
2W
VOLT.
REF
V10
OB2
1,5
2,4,7
R59
1MEG
C31
.01
R73
82K
5
-1,300V D-C
R65
27K
2W
6.3 V A-C
4
Z1
R66
33K
2W
C32
1
R75
620K
1W
REFL
VOLTS
ADJUST
CW
R250
100K
10W
TO
REFL
PROT
DIODE
V7
-300V TO
-2,000V
6.3 V A-C
3
Z2
R67
33K
2W
R76
620K
1W
R68
33K
2W
R77
620K
1W
-2000 V D-C
(SEE NOTE 2)
6
PART OF
TB 98
6
PART OF
TB 98
-2,000V D-C
TM689-39

NOTES.
1. UNLESS OTHERWISE SHOWN:
RESISTORS ARE IN OHMS AND ONE HALF WATT
CAPACITORS ARE IN UF
2. TERMINAL 6 IS AN INPUT AND OUTPUT LEAD.

Figure 409. Radio Transmitter T–303/G, electronic voltage regulator, schematic diagram.


1
E101
WHT-GRN
R141
R140
R139
R147
R142
R137
R143
R144
C160
R148
R149
R150
R153
R151
R155
CR6
R154
2
R145
3
E96
4
XV28
5
E98
6
XV29
E99
7
S1
8
E97
9
R146
10
R152
E100
11
TB88
WHT-GRN 11(4)
GRN 11(9)
WHT-BLK 9
WHT-BLK 1(6)
VIO 9
WHT-VIO 1(33)
YEL 11(10)
WHT-BLK 2
GRN
BRN-WHT 11(7)
BRN-GRN 11(6)
BLU 11(8)
WHT-VIO 11(2)
WHT 9
VIO 11(11)
GRN-WHT 11(13)
BRN 11(16)
BLK 11(17)
RED-GRN 11(18)
VIO 10
GRN-BLK 11(14)
WHT-VIO 1(19)
YEL
OR
BLU
GRN
YEL
ORN
BLU
BLK
11(1) VIO
1(3) VIO
1(10) WHT
2 WHT-BLK
11(5) WHT-BLK
1(15) VIO
11(15) BLK
7 VIO
1(8) WHT-VIO
2 WHT-GRN
9 WHT-BLK
4(4) BRN-GRN
4(3) BRN-WHT
4 BLU
2 GRN
1(5) YEL
1(24) VIO
1(12) GRN-WHT
1(29) GRN-BLK
10 BLK
6(3) BRN
6(4) BLK
6 RED-GRN
P
BASE LINE
TM 689-14

NOTE:
1. ALL SWITCHES ARE VIEWED FROM THE END OPPOSITE THE CONTROL KNOB, SECTIONS DESIGNATED ONE ARE NEAREST THE KNOB END
2 ALL WIRES DESIGNATED ARE TWISTED PAIRS

Figure 418. Radio Receiver R–418/G, afc and agc dc amplifier, wiring diagram.

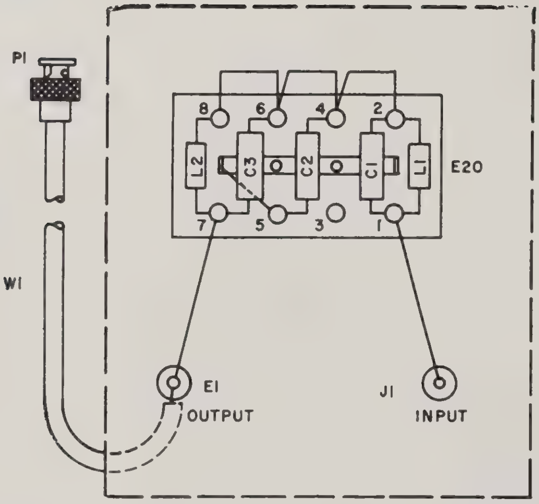

P1
8
6
4
2
L2
C3
C2
C1
L1
E20
7
5
3
1
W1
E1
OUTPUT
J1
INPUT
TM 689-23

Figure 422. Radio Transmitter T–303/G, video filter wiring diagram.

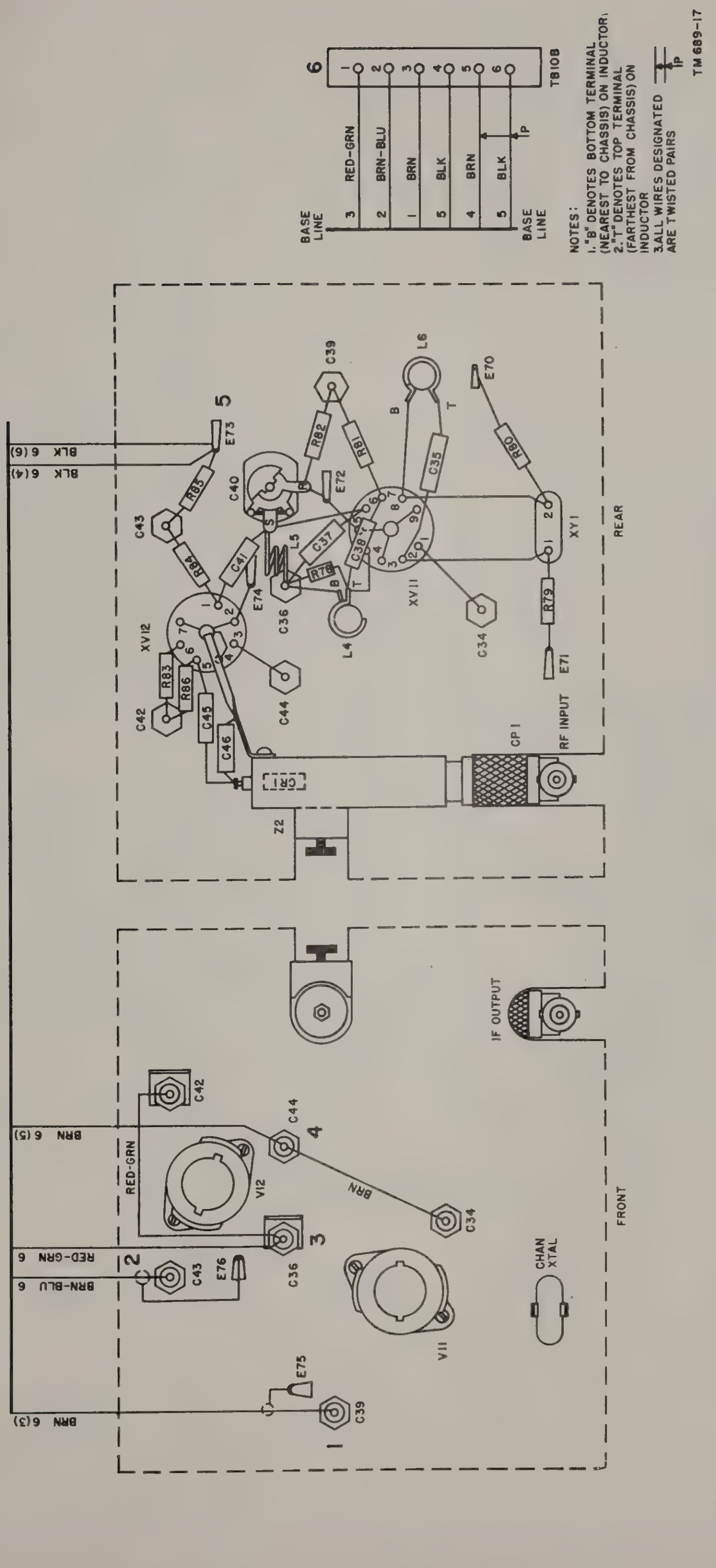

BRN 6(3)
BRN-BLU 6
RED-GRN 6
BRN 6(5)
BLK 6(4)
BLK 6(6)
1
2
3
4
5
6
C39
E75
C43
E76
C36
V11
CHAN XTAL
FRONT
V12
RED-GRN
BRN
C34
C44
C42
IF OUTPUT
Z2
CR1
CP1
RF INPUT
C45
C46
R83
R86
XV12
C42
C44
E74
C41
R84
C43
R85
E73
C40
E72
R82
R81
C39
L6
B
T
E70
R80
C35
XV11
C37
C38
R78
L5
S
L4
C36
C34
R79
E71
XY1
REAR
BASE LINE
3 RED-GRN
2 BRN-BLU
1 BRN
5 BLK
4 BRN
5 BLK
BASE LINE
P
TB108
NOTES:
1."B" DENOTES BOTTOM TERMINAL (NEAREST TO CHASSIS) ON INDUCTOR.
2."T" DENOTES TOP TERMINAL (FARTHEST FROM CHASSIS) ON INDUCTOR
3.ALL WIRES DESIGNATED ARE TWISTED PAIRS
TM 689-17

Figure 424. Radio Transmitter T-303/G, crystal multiplier wiring diagram.

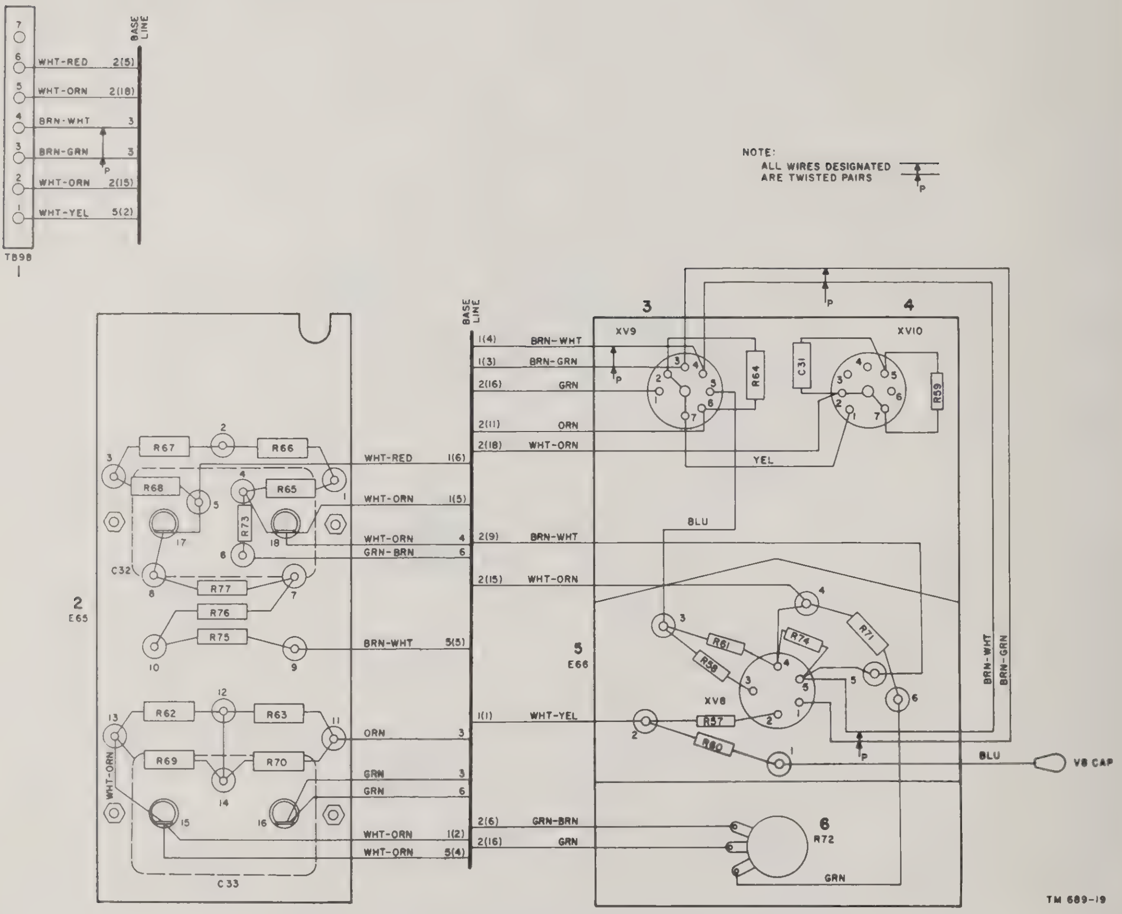

7
6 WHT-RED 2(5)
5 WHT-ORN 2(18)
4 BRN-WHT 3
3 BRN-GRN 3
P
2 WHT-ORN 2(15)
1 WHT-YEL 5(2)
BASE LINE
TB98
1
NOTE:
ALL WIRES DESIGNATED
ARE TWISTED PAIRS
P
BASE LINE
3
4
P
XV9
XV10
1(4) BRN-WHT
1(3) BRN-GRN
2(16) GRN
2(11) ORN
2(18) WHT-ORN
R64
C31
R59
YEL
BLU
R67
R66
R68
R65
R73
WHT-RED 1(6)
WHT-ORN 1(5)
WHT-ORN 4
GRN-BRN 6
2(9) BRN-WHT
2(15) WHT-ORN
C32
R77
R76
R75
2
E65
BRN-WHT 5(5)
5
E66
R61
R58
R74
R71
XV8
R57
R60
BRN-WHT
BRN-GRN
1(1) WHT-YEL
R62
R63
R69
R70
WHT-ORN
ORN 3
GRN 3
GRN 6
WHT-ORN 1(2)
WHT-ORN 5(4)
C33
2(6) GRN-BRN
2(16) GRN
6
R72
GRN
BLU
V8 CAP
TM 689-19

Figure 429. Radio Transmitter T–303/G, electronic voltage regulator, wiring diagram.

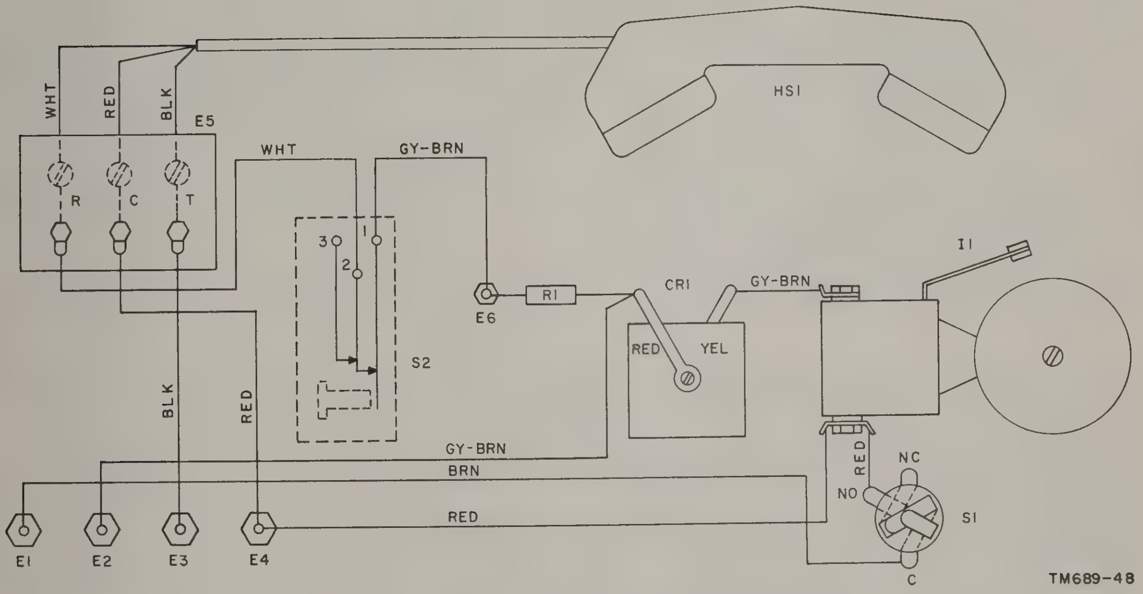
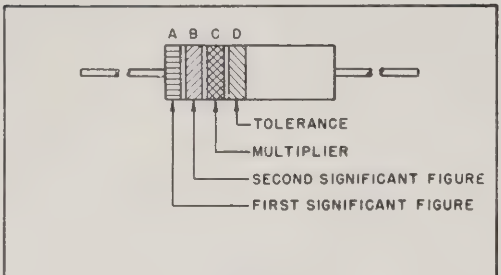

WHT
RED
BLK
E5
R
C
T
WHT
GY-BRN
3
2
1
S2
E6
RI
CRI
GY-BRN
RED
YEL
HSI
II
BLK
RED
GY-BRN
BRN
RED
RED
NC
NO
SI
C
EI
E2
E3
E4
TM689-48

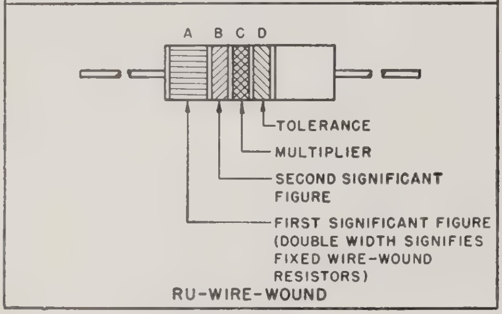
Figure 433. Handset-Signaling Unit H-102/TRC-29, overall wiring diagram.

RESISTOR COLOR CODE MARKING
(MIL-STD RESISTORS)

AXIAL-LEAD RESISTORS (INSULATED)

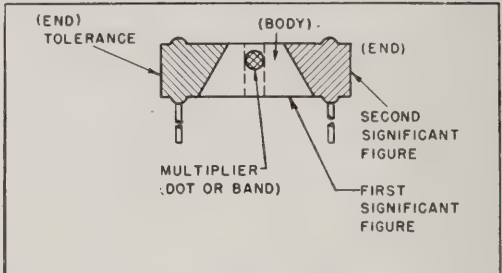

A B C D
TOLERANCE
MULTIPLIER
SECOND SIGNIFICANT FIGURE
FIRST SIGNIFICANT FIGURE

RC-COMPOSITION

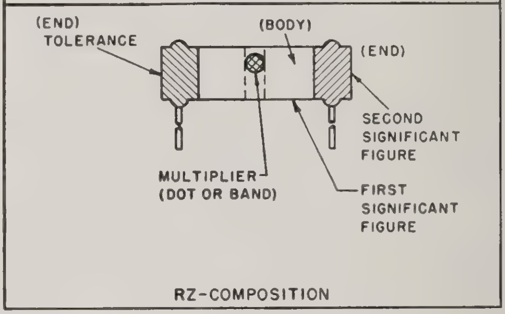

A B C D
TOLERANCE
MULTIPLIER
SECOND SIGNIFICANT FIGURE
FIRST SIGNIFICANT FIGURE (DOUBLE WIDTH SIGNIFIES FIXED WIRE-WOUND RESISTORS)

RU-WIRE-WOUND

RADIAL-LEAD RESISTORS (UNINSULATED)


(END) TOLERANCE
(BODY)
(END)
SECOND SIGNIFICANT FIGURE
MULTIPLIER (DOT OR BAND)
FIRST SIGNIFICANT FIGURE

RZ-COMPOSITION


(END) TOLERANCE
(BODY)
(END)
SECOND SIGNIFICANT FIGURE
MULTIPLIER (DOT OR BAND)
FIRST SIGNIFICANT FIGURE

RZ-COMPOSITION

RESISTOR COLOR CODE

BAND A OR BODY*		BAND B OR END*		BAND C OR DOT OR BAND*		BAND D OR END*	
COLOR	FIRST SIGNIFICANT FIGURE	COLOR	SECOND SIGNIFICANT FIGURE	COLOR	MULTIPLIER	COLOR	RESISTANCE TOLERANCE (PERCENT)
BLACK	0	BLACK	0	BLACK	1	BODY	± 20
BROWN	1	BROWN	1	BROWN	10	SILVER	± 10
RED	2	RED	2	RED	100	GOLD	± 5
ORANGE	3	ORANGE	3	ORANGE	1,000		
YELLOW	4	YELLOW	4	YELLOW	10,000		
GREEN	5	GREEN	5	GREEN	100,000		
BLUE	6	BLUE	6	BLUE	1,000,000		
PURPLE (VIOLET)	7	PURPLE (VIOLET)	7				
GRAY	8	GRAY	8	GOLD	0.1		
WHITE	9	WHITE	9	SILVER	0.01		

* FOR WIRE-WOUND-TYPE RESISTORS, BAND A SHALL BE DOUBLE-WIDTH. WHEN BODY COLOR IS THE SAME AS THE DOT (OR BAND) OR END COLOR, THE COLORS ARE DIFFERENTIATED BY SHADE, GLOSS, OR OTHER MEANS.

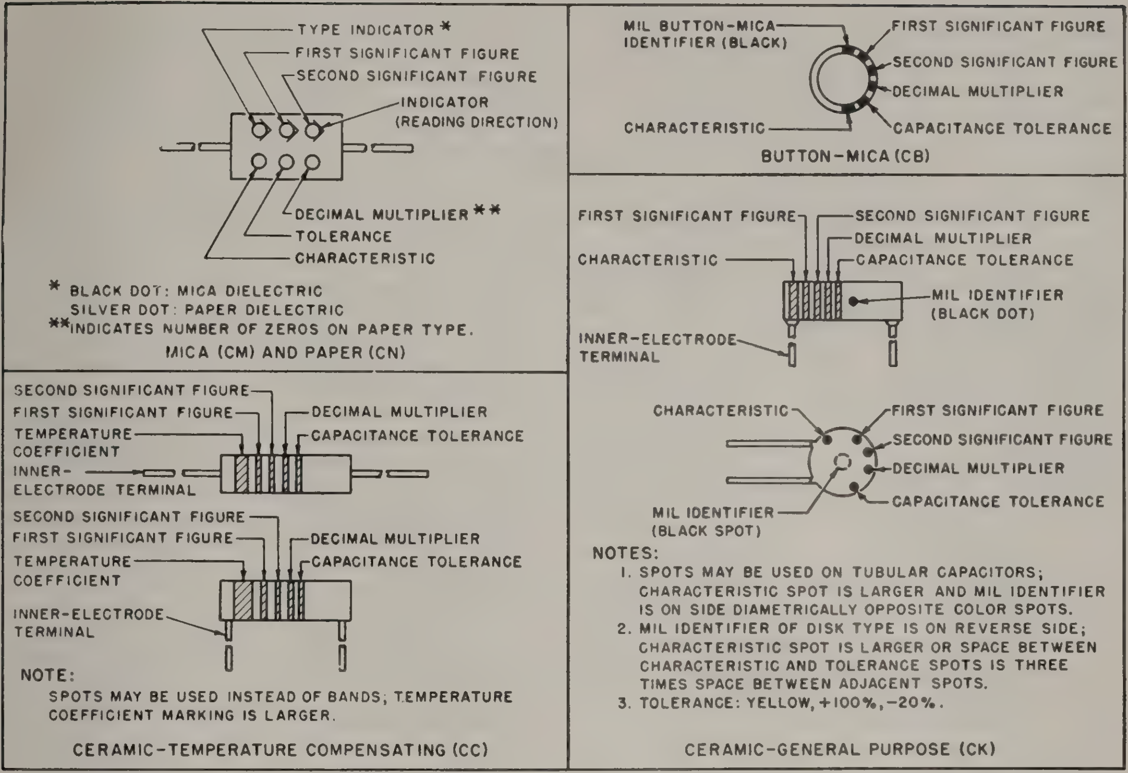
EXAMPLES (BAND MARKING):
10 OHMS ±20 PERCENT: BROWN BAND A; BLACK BAND B; BLACK BAND C; NO BAND D.
4.7 OHMS ±5 PERCENT: YELLOW BAND A; PURPLE BAND B; GOLD BAND C; GOLD BAND D.

EXAMPLES (BODY MARKING):
10 OHMS ±20 PERCENT: BROWN BODY; BLACK END; BLACK DOT OR BAND; BODY COLOR ON TOLERANCE END.
3,000 OHMS ±10 PERCENT: ORANGE BODY; BLACK END; RED DOT OR BAND; SILVER END.

STD-RI

Figure 434. Mil–STD resistor color code.

CAPACITOR COLOR CODE MARKING
(MIL-STD CAPACITORS)


TYPE INDICATOR *
FIRST SIGNIFICANT FIGURE
SECOND SIGNIFICANT FIGURE
INDICATOR (READING DIRECTION)
DECIMAL MULTIPLIER **
TOLERANCE
CHARACTERISTIC
MIL BUTTON-MICA IDENTIFIER (BLACK)
FIRST SIGNIFICANT FIGURE
SECOND SIGNIFICANT FIGURE
DECIMAL MULTIPLIER
CHARACTERISTIC
CAPACITANCE TOLERANCE
FIRST SIGNIFICANT FIGURE
SECOND SIGNIFICANT FIGURE
DECIMAL MULTIPLIER
CHARACTERISTIC
CAPACITANCE TOLERANCE
MIL IDENTIFIER (BLACK DOT)
INNER-ELECTRODE TERMINAL
CHARACTERISTIC
FIRST SIGNIFICANT FIGURE
SECOND SIGNIFICANT FIGURE
DECIMAL MULTIPLIER
CAPACITANCE TOLERANCE
MIL IDENTIFIER (BLACK SPOT)
SECOND SIGNIFICANT FIGURE
FIRST SIGNIFICANT FIGURE
DECIMAL MULTIPLIER
TEMPERATURE COEFFICIENT
CAPACITANCE TOLERANCE
INNER-ELECTRODE TERMINAL
SECOND SIGNIFICANT FIGURE
FIRST SIGNIFICANT FIGURE
DECIMAL MULTIPLIER
TEMPERATURE COEFFICIENT
CAPACITANCE TOLERANCE
INNER-ELECTRODE TERMINAL

* BLACK DOT: MICA DIELECTRIC
SILVER DOT: PAPER DIELECTRIC
**INDICATES NUMBER OF ZEROS ON PAPER TYPE.

MICA (CM) AND PAPER (CN)

BUTTON-MICA (CB)

NOTES:

1. SPOTS MAY BE USED ON TUBULAR CAPACITORS; CHARACTERISTIC SPOT IS LARGER AND MIL IDENTIFIER IS ON SIDE DIAMETRICALLY OPPOSITE COLOR SPOTS.
2. MIL IDENTIFIER OF DISK TYPE IS ON REVERSE SIDE; CHARACTERISTIC SPOT IS LARGER OR SPACE BETWEEN CHARACTERISTIC AND TOLERANCE SPOTS IS THREE TIMES SPACE BETWEEN ADJACENT SPOTS.
3. TOLERANCE: YELLOW, +100%, -20%.

CERAMIC-GENERAL PURPOSE (CK)

NOTE:

SPOTS MAY BE USED INSTEAD OF BANDS; TEMPERATURE COEFFICIENT MARKING IS LARGER.

CERAMIC-TEMPERATURE COMPENSATING (CC)

CAPACITOR COLOR CODE

COLOR	SIG FIG.	MULTIPLIER		CHARACTERISTIC[1]				TOLERANCE [2]					TEMPERATURE COEFFICIENT (UUF/UF/°C)
		DECIMAL	NUMBER OF ZEROS	CM	CN	CB	CK	CM	CN	CB	CC		
											OVER 10UUF	10UUF OR LESS	CC
BLACK	0	1	NONE		A			20	20	20	20	2	ZERO
BROWN	1	10	1	B	E	B	W				1		-30
RED	2	100	2	C	H		X	2		2	2		-80
ORANGE	3	1,000	3	D	J	D			30				-150
YELLOW	4	10,000	4	E	P								-220
GREEN	5		5	F	R						5	0.5	-330
BLUE	6		6		S								-470
PURPLE (VIOLET)	7		7		T	W							-750
GRAY	8		8			X						0.25	+30
WHITE	9		9								10	1	-330(±500) [3]
GOLD		0.1						5		5			+100
SILVER		0.01						10	10	10			

1. LETTERS ARE IN TYPE DESIGNATIONS GIVEN IN MIL-C SPECIFICATIONS.
2. IN PERCENT, EXCEPT IN UUF FOR CC-TYPE CAPACITORS OF 10 UUF OR LESS.
3. INTENDED FOR USE IN CIRCUITS NOT REQUIRING COMPENSATION.

STD-C1

Figure 435. Mil-STD capacitor color code.

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